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Bulletin of the British Ornithologists' Club

Volume 123A – Supplement. 2003

Why Museums Matter:

Avian Archives in an Age of Extinction

Edited by Nigel Collar, Clem Fisher & Chris Feare

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3rd European Symposium of Bird Curators

Following the first two European conferences on bird collections, in Tring in 1999 and in Bonn in 2001, the 3rd Conference will be held in the National Museum of Natural History in Leiden, the Netherlands, from Friday 10 - Sunday 12 October 2003.

The scientific programme will be organised by the Bird Department of the National Museum of Natural History, starting early 2003. Ideas and suggestions for the scientific programme are welcome: please forward these to Dr. René W.R.J. Dekker at dekker@naturalis.nnm.nl

The logistics of the conference will be organised by the Leids Congres Bureau (LCB). The LCB will be responsible for conference registration, hotel reservations, mailings, etc., and will contact you by email early 2003.The conference will take place in the Auditorium of the National Museum of Natural History in Leiden, which is only a 5 minutes walk from the Leiden central railway station. Your accommodation may be able to be arranged within walking distance. Leiden can be reached by train from Schiphol airport in only 15 minutes.

The conference fee, which includes registration, documentation, lunch (2), tea and coffee (but not dinner and hotel reservations), will be approximately 175-200 Euro.

Programme: Friday 10 October 2003 - afternoon: arrival and registration; Saturday 11 and Sunday 12 October 2003 - lectures and panel discussions.

The NEW bird collection is open for study during the week, but NOT on Saturday and Sunday during the conference.

If you would like to receive future mailings about the 3rd European Conference on Bird Collections in October 2003 in Leiden, please send an email to dekker@naturalis.nnm.nl

Bulletin of the British Ornithologists' Club 2003

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Why Museums Matter:
Avian Archives in an Age of Extinction

Papers from a conference of this title
held at Green Park, Aston Clinton, and
workshops at the Natural History Museum,
Tring, 12-15 November 1999

Edited by
Nigel J Collar, Clemency T Fisher
and Chris J Feare

Phillip Alexander Clancey

The publication of these conference proceedings as a supplement to the *Bulletin of the British Ornithologists' Club* has been made possible by a generous legacy to the Club by the late Dr Phillip Clancey. Dr Clancey contributed specimens to and used museums extensively during his studies on the taxonomy of African birds (see his Obituary – *Bull. B.O.C.* 121: 217-218 (2001)) and wished his legacy to be used to support the *Bulletin*, in which he published many of his findings.

It seems fitting that Dr Clancey's legacy should be used to highlight the continuing importance of museums as archives for historic and current collections of ornithological material and we are pleased to dedicate this volume to his memory.

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Editors' commentary and acknowledgements

If publication of any set of symposium papers is delayed, it becomes increasingly problematic to follow through the standard editing process of refereeing and negotiation with authors over the final version of their contributions. The difficulty largely derives from the fact that material left unpublished too long begins to date, and it becomes uncertain whether it is better to leave the contributions as they were at the time they were made, or to update them in the light of more recent publications. Decisions either way can create a sense of loss of authenticity. Some authors in the present proceedings declined to include new material relevant to their subject; others chose to include some, opportunistically; still others provided a comprehensively up-to-date version of their papers. However, the discrepancies are not striking, and we strongly commend these proceedings as a relevant, comprehensive and topical collective review of the values of museums in ornithology. We also note that, meanwhile, other assertions of the value of museum collections of birds have been no less insistent (e.g. Griffiths & Bates 2002, Oniki 2002).

These proceedings are the first of what we now expect to be a series documenting meetings of bird curators held in Europe to discuss and promote cooperation between museums. The meeting at the Natural History Museum's Bird Department at Tring in Hertfordshire in November 1999 engendered a second conference in Bonn in November 2001. The Bonn proceedings are due to appear approximately at the same time as those from Tring, in early 2003 (Rheinwald in press). A third conference is scheduled to be held in Leiden in October 2003, and doubtless its proceedings will appear in due course.

Profound apologies must be extended to the authors for the delay in editing their contributions, but we must also thank them all warmly for their very positive response to our requests for their rapid cooperation. We also thank those who in mid-year 2002 most generously undertook to referee the papers, at very short notice and with very short turn-around times: P. Andrew, T. M. Brooks, L. Christidis, J. H. Cooper, E. C. Dickinson, J. Fjeldså, R. E. Green, H. Jakober, I. Newton, R. B. Payne, R. P. Prŷs-Jones, C. S. Roselaar, D. W. Snow, W. Stauber, F. D. Steinheimer and R. Yosef. We also thank the British Ornithologists' Union and British Ornithologists' Club, particularly S. P. Dudley, C. J. Feare and T. W. Gladwin, for their strong encouragement and support in bringing the editing of these proceedings to a conclusion.

Griffiths, C. S. & Bates, J. M. 2002. Morphology, genetics and the value of voucher specimens: an example with *Cathartes* vultures. *J. Raptor Res.* 36: 183-187.

Oniki, Y. 2002. Another value of specimens in museum collections. *Ornitologia Neotropical* 13: 323-324.

Rheinwald, G., (ed.) In press. Conference Proceedings of the Second European Symposium 'Bird Collections in Europe: The Challenges of Mutual Cooperation'. *Bonn. zool. Beitr.* 51(3–4).

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After the delays to which Nigel Collar and Clem Fisher have referred above, the decision to publish these proceedings as a supplement to the *Bulletin of the British Ornithologists' Club* was made only in late 2002. By the time the texts began to fall on to my desk in December 2002, the bulk of the editing had been completed and we set the somewhat daunting target of publishing the supplement in March 2003. My task was largely to convert the style to *Bulletin* format and to send the texts to the authors for final approval, during which I did seek clarifications and revisions. I am grateful to Nigel and Clem for the huge editorial job that they had already done, and to the authors for responding so rapidly to my appeals for urgent attention to the final details. This rapid publication also involved speedy processing by our typesetter, Alcedo Publishing, and our printer, Crowes of Norwich, and I am grateful to them for making it possible.

Chris Feare
Hon. Editor, *Bulletin of the British Ornithologists' Club*

Introduction

by Robert Prŷs-Jones

My desire to plan the conference '*Why Museums Matter: Avian Archives in an Age of Extinction*' and its associated workshop '*Increased Co-operation between Museum Bird Collections, especially in Europe*' arose out of two interrelated facts which had become apparent to me in my role as collection manager of one of the world's largest bird collections. First, in an era of ever-rising threats to ever more bird species worldwide, it was increasingly important to improve cooperation between museums in collating and making available information about the bird specimen resources they look after. Second, such cooperation would most easily arise out of personal contact, but at the time no forum existed, at least within Europe, to facilitate the meeting and exchange of views among bird collection management staff.

The aim was therefore to organise a conference containing a suite of papers focusing comprehensively on the content and value of bird collections and on research arising directly out of them, but avoiding undue overlap with previously published reviews (e.g. Miller 1985). Although open to all interested parties, the core target audience would comprise representatives with hands-on collection management responsibilities from as many European museums containing significant bird collections as possible, but leavened with a cross-section of speakers from museums elsewhere, and indeed from other relevant backgrounds, to provide wider perspectives. This would be followed by a workshop, open only to museum personnel, aimed at facilitating a structured general discussion of issues of common concern and priorities for future cooperative action. The focus on European museum staff seemed desirable both because the continent is a coherent entity which contains numerous important bird collections, hitherto lacking any interaction of the type achieved by their U.S. equivalents at, for example, American Ornithologists' Union meetings and through the electronic discussion forum AVECOL, and because funding and logistical constraints precluded any comprehensive worldwide approach.

Given that the whole enterprise was undertaken on a shoestring budget, the response and outcome were gratifying. Approximately 130 people from 25 countries attended, including representatives from the great majority of larger, and some smaller, European bird collections. The conference speakers, almost all of whom attended at their own expense, must be congratulated for sticking to their briefs and producing contributions of a high standard, as is fully evident from these published proceedings (for reviews of the event, see Brooke 2000 and Cooper 2000). The workshop discussions, summarised herein (see under Cooper & Steinheimer), were lively and constructive, and have led directly to a number of initiatives, such as the setting up of eBEAC (the electronic Bulletin for European Avian Curators), and a strong stimulus towards the goal of a world avian type specimen list. Perhaps the best indication that a real need was being addressed came through the general agreement that the meeting should become the first of a biennial series, with staff of the Alexander Koenig Research Institute and Museum of Zoology, Bonn, Germany, hosting a second European Bird Curators' symposium in 2001, and with plans well advanced now for a third in the National Museum of Natural History, Leiden, The Netherlands in 2003.

In planning and carrying through this enterprise, I was fortunate in the variety of assistance that became available from both individuals and organisations. The British Ornithologists' Union accepted the conference as one of its regular series, making freely available its administrative and publicity machinery and the able organising skills of its staff, Steve Dudley and Gwen Bonham. The British Ornithologists' Club provided funding to support attendance of the conference and workshop by museum personnel who would otherwise have been precluded from coming, as well as supporting the publication of these proceedings. The Natural History Museum allowed its Bird Group staff to take time to plan and organise the conference and workshop, and permitted use of the Walter Rothschild Zoological Museum for the conference reception. BirdLife International also lent its support to the enterprise, signalling clearly its recognition of natural history museums as key players in conservation science.

Scientific organisation of the entire event was shared between Drs Nigel Collar, Clem Fisher, Kees Roselaar and myself. As well as his role in running the workshop, Kees Roselaar has made a particularly noteworthy contribution in compiling the European bird collections directory that is published in these proceedings and which will hopefully soon be available on-line. Professor Sir Robert May, then U.K. Government Chief Scientific Advisor, graciously agreed to give the opening address. Mark Adams, Joanne Cooper, Steven Parry, Jörn Scharlemann, Don Smith, Frank Steinheimer and Michael Walters of the NHM Bird Group played indispensable roles in assisting with all the logistical requirements necessary to ensure the programme ran smoothly. Dr Andrew Richford (Academic Press) kindly underwrote the cost of refreshments for the conference reception.

The production of these proceedings has been delayed for reasons which fall very largely at my door and for which I apologise to all contributors. Their appearance now is due almost entirely to the efforts of Nigel Collar, who has played very much the leading role in collating and editing the contents of this volume. The whole enterprise has been a satisfying one to be associated with and hopefully will have a legacy of lasting value.

References:
Brooke, M. de L. 2000. Why museums matter. *Trends Ecol. Evol.* 15: 136-137.
Cooper, J. 2000. Report on "Why museums matter". *Ibis* 142: 347-348.
Miller, E. H. (ed.) 1985. Museum collections: their roles and future in biological research. *Occasional Papers of the British Columbia Provincial Museum* 25.

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Avian zoogeography, speciation and the museum tradition

by Jürgen Haffer

SUMMARY

Zoogeographical studies involving the identification of speciation patterns in birds have been greatly facilitated by the preparation of distribution maps using published localities and unpublished museum specimen records. Zoogeographical patterns in Amazonian birds include six conspicuous areas of endemism and numerous sharply defined contact zones between closely related geographically representative birds. Many contact zones cluster along the Amazon and the lower portions of its tributaries, but others cross river courses at rightangles. Parapatric contact zones generate many important riddles over the processes whereby species remain intact (do the zones remain stationary or fluctuate, how is parapatry maintained, why and when did it originate? etc.); parapatric patterns in New Guinea lowland birds offer further opportunities to solve such questions. Studies based on museum collections continue to contribute valuable data on the character geography of particular species groups (in the case of migrant Arctic waders based on extensive quantification of subtle character differences between populations), on geographical variation of sexual dimorphism, and geographically variable polymorphism.

Introduction

Bird collections in natural history museums document the occurrence of common, rare, threatened and extinct species obtained in accessible and inaccessible areas of the world. Collections form the basis of systematic and zoogeographic studies, for research on geographic variation, study of plumage colour patterns, ecomorphology, biodiversity and many other topics. Early private and public collections were already important during the period when ornithology originated as a separate branch of zoology during the first half of the nineteenth century. Later, scientists and commercial collectors travelled widely overseas contributing to the rapid growth of the regional knowledge of the avifaunas of the world, and leading to a conspicuous boom in bird collections during the second half the nineteenth century and into the twentieth century (Stresemann 1975, Barrow 1998, Mearns & Mearns 1998, Haffer 2001, Glaubrecht 2002).

Below I demonstrate the constant and non-substitutable relevance of museum collections to the topic of avian zoogeography, in particular the mapping of breeding and wintering ranges of birds, the study of individual and geographic variation, the analysis of contact zones between subspecies and species as well as of areas of endemism. I show that bird collections stored in museums are essential tools for such research. Conceptual contributions of systematists to biological science through specimen-based research include the theory of geographical speciation, the principle of population thinking, and the interpretation of the gradualness of evolution.

Mapping of breeding and wintering ranges

Precise locality data and the dates of collecting are the basic information on specimen labels needed for taxonomic and zoogeographic work. Such notes are often supplemented by data on the colour of bill, feet, iris and skin around the eye, as well as by information on moult and stomach contents. The field notebooks of the collectors frequently provide information on the ecology and calls of particular birds. Obviously, the correct labelling of museum specimens, as to where and when a bird was taken, is of crucial importance, including information on the altitude of the collecting locality, especially in mountains, and its position with respect to the left or right bank of a broad river. Occasional misidentifications of birds can only be clarified through reference to preserved specimens.

Locality data are utilised in taxonomic and faunistic publications as well as in regional atlas projects like those which have been published for Palearctic and African birds. In the Palearctic atlas (Stresemann, Portenko *et al.* 1960–2000) the limits of the breeding ranges of selected species are mapped and the localities used to trace these range limits are documented in the accompanying text of each map, which also includes discussions of the ecology and taxonomy of these birds. The detailed documentation of all localities as to their literature source permits their verification in case of later need. So far 19 instalments of this atlas treat 210 species of birds in 62 genera which have been studied cooperatively by 16 scientists, mainly at the Berlin and St. Petersburg Zoological Museums.

The atlases of African passerine (Hall & Moreau 1970) and non-passerine birds (Snow 1978) map the distributions of more or less related and geographically representative species onto a background vegetation map of Africa. Each locality where a species has been collected is marked with a particular symbol (solid or open circle, triangle, square, etc.). Such presentation permits at-a-glance appreciation of the ecological occurrence of a species, its relative abundance (few or many locality records) and the location of contact zones, i.e. areas of geographic replacement, between related representatives (with or without hybridisation). These aspects would not be so obvious if the distribution of each member species of such superspecies or species groups had been illustrated on a separate map. Numerous opportunities for field studies become apparent simply by studying these African maps.

Although the use of point-locality mapping in these African atlases is extremely valuable as a means of establishing baseline distributions, there are two drawbacks (N. J. Collar pers. comm.): (1) the mapped locality records are not tagged with a source, so that in cases of doubt they cannot be scrutinised; and (2) not all sources have been used and certain information is missing. In a less detailed manner, Moreau (1972) mapped and discussed the summer and winter distributions of all Palearctic migratory birds.

South America has immense potential for mapping species distributions thanks to the extraordinary programme of gazetteer production for every South American country by R. A. Paynter (Harvard University, Cambridge, Massachusetts) and

M. A. Traylor (Field Museum of Natural History, Chicago). Each volume compiles all geographic localities in the ornithological literature, together with hundreds of unpublished localities represented in the world's major ornithological collections. Each entry lists the coordinates of the locality, elevation, habitat notes, and dates visited by the respective ornithological collector(s); see, e.g., the gazetteers by Paynter & Traylor (1991) for Brazil and by Paynter (1993, 1997) for Ecuador and Colombia. In the future, these and other gazetteers will permit the precise mapping of all South American species ranges for detailed biogeographical analyses, which so far have been based on less comprehensive datasets. When the complete distribution maps are available, it will be quite easy also to determine, for example, the coverage of the neotropical lowlands by museum samples and which museum collection contains the best representation of the bird fauna of a particular region in South America.

Zoogeographical aspects of the Amazonian bird fauna

I summarise below some results of my research based on studies of the birds preserved in the collections of several North American and European museums.

Areas of endemism

The ranges of many bird species and well-differentiated subspecies cluster in fairly restricted regions of the continents, characterising 'areas of endemism'. Other authors have designated such regions 'centres of endemism', 'distribution centres', 'core areas' and 'dispersal centres.' Six main areas of endemism are developed in Amazonia (Haffer 1969, 1974, 1978, Müller 1973, Cracraft 1985). Each of these areas is characterised by 10–50 species. By superimposing their ranges and contouring their numbers, areas of maximal overlap of breeding ranges of each species group are emphasised. These six areas of endemism are located in peripheral regions of Amazonia (Napo, Inambari, Imerí, Rondônia, Guiana and Belém). More widespread species inhabit increasingly larger distribution areas comprising two or more areas of endemism. Several groups of birds composed of geographically representative species characterising the several areas of endemism form conspicuous mosaic distribution patterns over all of Amazonia (e.g. *Pionopsitta* parrots, *Selenidera* toucanets, *Ramphastos* toucans and *Pipra* manakins).

In their global survey of endemism in birds, Stattersfield *et al.* (1998) identified only those areas of endemism ('endemic bird areas' or EBAs) which are characterised by at least two species with ranges of less than 50,000 km² each. They left unmapped other areas of endemism where the most restricted species have slightly larger ranges. This is the reason why in Amazonia only the Napo, Inambari and Imerí areas appear on their map (under slightly different names), whereas the very conspicuous areas of endemism of Guiana, Belém and Rondônia remained unidentified. This is not meant as a criticism but to point out the problem when a practical criterion (i.e. 50,000 km²) within the framework of conservation biology is used as a cut-off for biogeographic mapping in a huge lowland plain with no major barriers like Amazonia.

Contact zones between subspecies and species of birds

Many Amazonian birds meet and exclude each other geographically with or without hybridisation along sharply defined contact zones. These areas of contact represent major zones of biogeographic discontinuity in a continuous forest environment (Fig. 1, Table 1). Such pairs of taxa inhabit different levels of the forest; some prefer the canopy, others the middle levels and still others the understorey. Contact zones may or may not follow rivers at least for some distance.

As examples of conspicuous contact zones, I illustrate the distribution of three manakin species of the genus *Pipra* which inhabit forests near lowland rivers and are very common in many regions of Amazonia (Fig. 2). The males are mainly black, bright red and yellow; the females are inconspicuously green and similar to one another. Wire-tailed Manakin *P. filicauda* is slightly larger than the other two species; its tail feathers are elongated and their shafts project as long wire-like filaments (shorter in females). This species inhabits most of upper Amazonia (north to the coast of Venezuela), whereas Crimson-hooded Manakin *P. aureola* is found in the forests along the lower Amazon and Madeira Rivers as well as along the coastal lowlands of the Guianas. Band-tailed Manakin *P. fasciicauda* (with a white basal tail-band) occupies southern Amazonia and extended its range into north-eastern

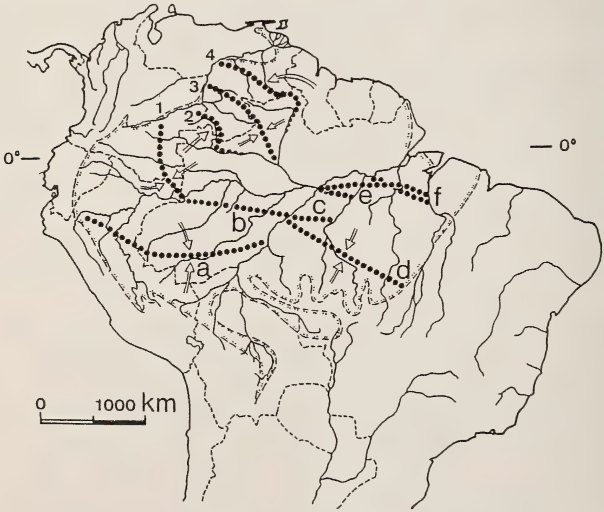


Fig. 1. Contact zones between selected Amazonian forest birds whose locations are independent of or variously displaced by river courses. For explanations of figures and letters see Table 1.

TABLE 1

Some species and subspecies of birds which form conspicuous contact zones in Amazonia (numbers and letters refer to Fig. 1).

I. North of the Amazon River; western representatives named first.

1	Ramphastidae	*Selenidera reinwardtii*	*S. nattereri*
2	Formicariidae	*Gymnopithys leucaspis*	*G. rufigula*
3	Ramphastidae	*Ramphastos vitellinus culminatus*	*R. v. vitellinus*
		Ramphastos tucanus cuvieri	*R. t. tucanus*
	Picidae	*Veniliornis affinis*	*V. cassini*
4	Psittacidae	*Pionopsitta barrabandi*	*P. caica*
	Ramphastidae	*Pteroglossus pluricinctus*	*P. aracari*
		Selenidera nattereri	*S. culik*
	Picidae	*Celeus grammicus*	*C. undatus*

II. South of the Amazon River; the southern representatives are named first.

a	Cuculidae	*Neomorphus geoffroyi*	*N. pucheranii*
	Pipridae	*Pipra fasciicauda*	*P. filicauda*
		Pipra coronata exquisita group	*P. c. coronata* group
b	Galbulidae	*Galbula tombacea*	*G. cyanescens*
c	Psittacidae	*Pionopsitta barrabandi*	*P. vulturina*
	Galbulidae	*Galbula rufoviridis*	*G. galbula*
	Capitonidae	*Capito dayi*	*C. brunneipectus*
	Ramphastidae	*Pteroglossus beauharnaesius*	*P. aracari*
	Cotingidae	*Xipholena punicea*	*X. lamellipennis*
d	Ramphastidae	*Ramphastos vitellinus pintoi*	*R. v. ariel*
	Dendrocolaptidae	*Xiphorhynchus elegans*	*X. spixii*
	Formicariidae	*Hylophylax poecilinota griseiventris*	*H. p. nigrigula*
	Pipridae	*Pipra nattereri*	*P. iris*
	Troglodytidae	*Thryothorus genibarbis*	*T. coraya*
e	Cotingidae	*Phoenicircus nigricollis*	*P. carnifex*
f	Pipridae	*Pipra fasciicauda*	*P. aureola*

and central Brazil. Where these species meet they replace each other geographically along sharply defined contact zones without (or very rarely) hybridising (parapatry). The contact zone between *P. aureola* and *P. fasciicauda* crosses the southern tributaries of the lower Amazon River at rightangles. The same is the case with the contact zone between *P. fasciicauda* and *P. filicauda* in upper Amazonia which crosses the Purús, Juruá and Ucayali Rivers at more or less rightangles. The situation along the upper Rio Juruá (Fig. 3) demonstrates the sharp replacement of these species in the uniformly distributed forests around the small village of Sobral where one male and three females of *filicauda* and two males of *fasciicauda* have been collected. Hybridisation does not seem to occur. To the south of Sobral, only *P. fasciicauda* is encountered in the forests to Taumaturgo and the Rio Tejo, a distance of 50 km (20

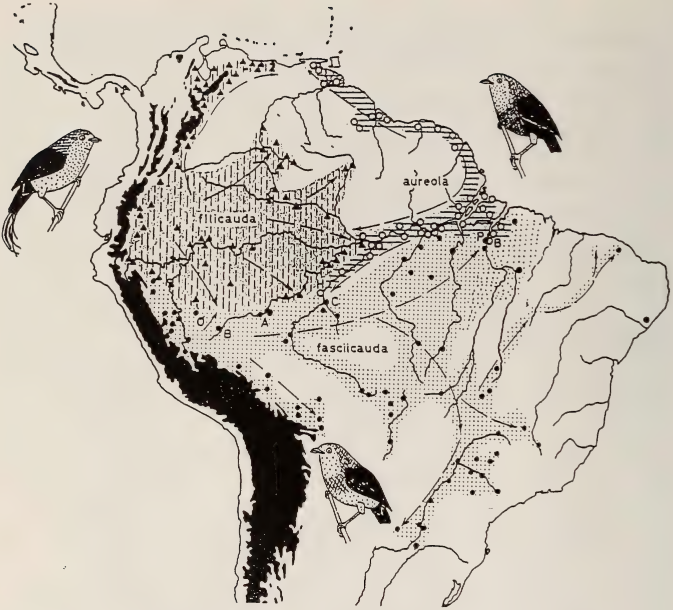
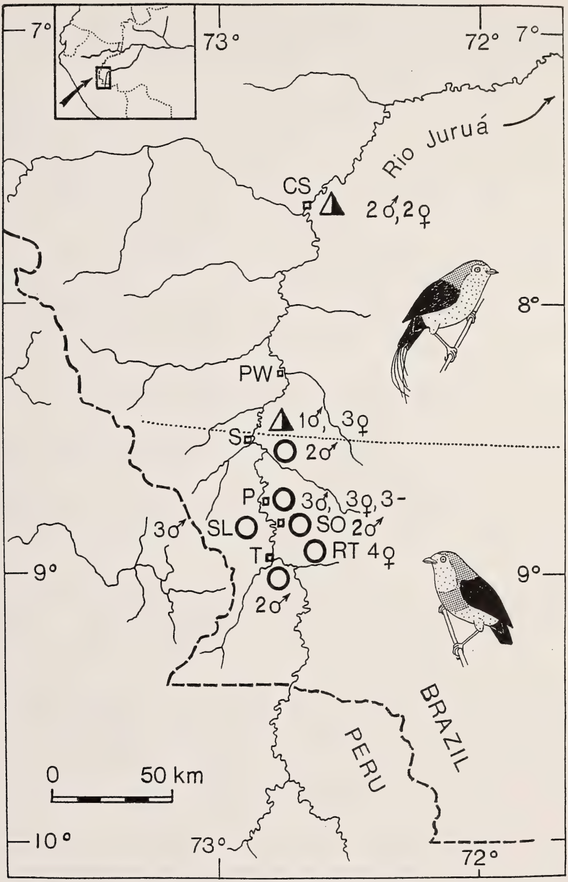


Fig. 2. Distribution of manakins of the *Pipra aureola* superspecies (males illustrated; plumage colour is yellow, red, orange and black). Locality records (symbols) refer to the following species: Crimson-hooded Manakin (*P. aureola*, open circles and horizontal hatching), Band-tailed Manakin (*P. fasciicauda*, solid circles and stippling), and Wire-tailed Manakin (*P. filicauda*, solid triangles and vertical dashes).

specimens in the Museu Paraense E. Goeldi, Belém, Pará). North of Sobral presumably only *P. filicauda* occurs. Details of the ecological relations between these two species will have to be determined through fieldwork around the village of Sobral.

Many contact zones cluster along the Amazon River and along the wide lower portions of some of its tributaries (Haffer 1978). However, the most important zoogeographical aspect of Amazonian contact zones is the fact that the locations of many other such zones are *independent* of river courses, crossing even the largest ones at rightangles, including the Amazon River itself. Examples of upper/lower Amazonian taxa whose contact zones in central Amazonia cross the middle or lower Amazon River from north to south are the following: Cobalt-winged Parakeet *Brotogeris cyanoptera* / Golden-winged Parakeet *B. chrysopterus*, 'Cuvier's Toucan'


7°
73°
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7°
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9°
9°
10°
73°
72°
Rio Juruá
CS
2♂, 2♀
PW
1♂, 3♀
S
2♂
P
3♂, 3♀, 3-
3♂
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RT 4♀
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Fig. 3. Parapatric contact between Wire-tailed Manakin (*Pipra filicauda*, above and triangles) and Band-tailed Manakin (*P. fasciicauda*, below and circles) along the upper Rio Juruá in westernmost Brazil. Sketches illustrate adult males. Collecting localities from north to south are Cruzeiro do Sul (CS), Sobral (S; both species!), Porongaba (P), Igarapé Sao Luis (SL), Seringal Oriente (SO), Taumaturgo (T), and Rio Tejo (RT). PW Porto Valter. Dashed line follows border between Brazil and Peru.

Ramphastos t. cuvieri / 'Red-billed Toucan' *R. t. tucanus* and Rufous-bellied Euphonia *Euphonia rufiventris* / Golden-sided Euphonia *E. cayennensis*. The rich collections in several museums facilitated a detailed analysis of some of these contact zones (Haffer 1974, 1997).

I should clarify here the terminology I use. Geographically representative taxa of birds which meet without a separating barrier in an ecologically rather uniform area either hybridise more or less extensively along their contact zone or they exclude each other geographically with no (or only very restricted) hybridisation. In the former case these taxa represent subspecies of one biological species, whereas in the latter case they are differentiated at the species level. Such geographically representative species in contact are designated as 'parapatric' to distinguish them from sympatric (co-occurring) and allopatric (widely separated) species. Among the examples mentioned above, the representatives of *Brotogeris* and *Euphonia* are parapatric species, whereas those of the *Ramphastos* toucans hybridise extensively where they meet in central Amazonia. The intermediate populations are highly variable and composed exclusively of hybrid individuals; parental phenotypes are lacking. Under the biological species concept, *Ramphastos t. cuvieri* and *R. t. tucanus* are subspecies of the White-breasted Toucan *R. tucanus*. As mentioned above, the term 'parapatric' usually refers to species only, although some authors do speak of 'parapatric subspecies' in those cases where the connecting hybrid zone is very narrow (which is not the case in the toucans).

The members of parapatric species pairs probably compete ecologically and would extend their ranges across the contact zone but for the existence there of the competing ally (Haffer 1992). These contact zones are located in uniform (but complex) vegetation zones or in gradually changing habitat zones where, however, the ecological gradients are not steep enough to explain the abrupt replacement of the representatives. Each of them appears to be superior to the other in the respective area occupied. In the Eastern Andes of Peru, approximately two-thirds of the altitudinal distribution limits of bird species are due to ecological competition (Terborgh 1985). Competitive exclusion is one of the most important factors determining the composition of this rich bird fauna. The frequent occurrence of geographical exclusion of species along contact zones in the Amazonian lowlands as well as ecological exclusion of species within the rain forest through vertical stratification (Terborgh 1980) supports a similar interpretation of the importance of ecological competition for the determination of the regional composition of this rich tropical lowland avifauna.

Still to be determined for most or all instances of parapatric contact zones between bird species in Amazonia are:

(1) What is the situation regarding the local distribution of the representative species? Do the contact zones remain stationary or do they fluctuate regionally or shift gradually in a certain direction?

(2) In what manner is each zone of parapatry maintained, i.e. why do parapatric species not penetrate rach other's ranges? Do agonistic behavioural responses

(interference competition) or resource preemption (exploitation competition) by their respective representatives prevent parapatric species from overlapping their ranges? Which mechanisms assure reproductive isolation of the species along their zone of contact? Does reinforcement of pre-mating isolating mechanisms and/or of ecological segregation between the species take place at the contact zones (i.e. will the two taxa gradually become more different in behaviour, calls, ecological preferences, etc.)?

(3) Why did parapatry originate in each case? Are the locations of contact zones the results of historical causes or of current ecological conditions? In instances of sympatry, these species might be expected to maintain interspecific territories or to occupy mutually exclusive patchy areas of varying extent.

(4) When did the parapatric species originate and when did they establish contact?

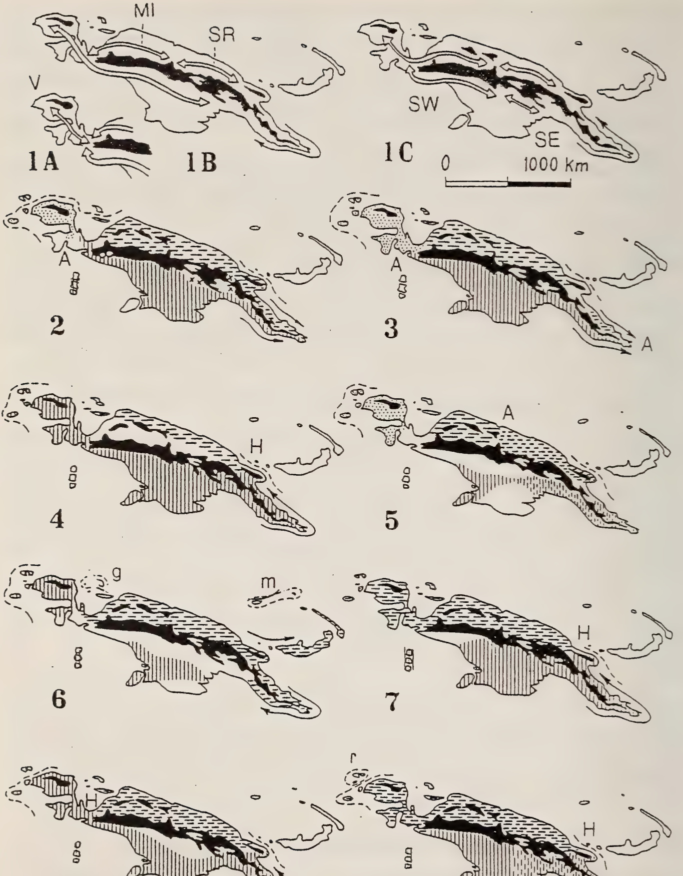
As examples of detailed taxonomic and zoogeographical analyses of contact zones with and without hybridisation of the taxa involved I cite the publications of Meise (1928, 1975), Short (1965), Remington (1968), Haffer (1977), and Panov (1989), all of which are based on extensive museum studies of bird collections.

Zoogeographical aspects of the avifauna of New Guinea

As in Amazonia, conspicuous areas of endemism and contact zones between birds are found in the lowlands of New Guinea. The bird faunas of the forested northern and southern lowlands are separated by the enormous 'wall' of the central mountain range extending for 2,000 km from the Geelvink Bay in the north-west to the south-eastern tip of the island. The following lowland regions are zoogeographically significant as areas of endemism (Stresemann 1936, Pratt 1982, Beehler *et al.* 1986): (1) the Vogelkop region at the north-western end of New Guinea; in northern New Guinea the basins (2) of the rivers Mamberano–Idenburg and (3) of the rivers Sepik–Ramu; (4) the lowlands of southern New Guinea. Examples of characteristic distribution patterns of lowland New Guinea birds are summarised in Fig. 4 and Table 2.

Many taxa of southern New Guinea extended their ranges westward beyond the Geelvink Bay into the Vogelkop region of NW New Guinea (Fig. 4/1B). In other cases the representatives of northern New Guinea reached the Vogelkop region first (Fig. 4/1C) or an endemic form exists in the latter area and three geographical representatives are in contact in the lowlands around the Geelvink Bay (Fig. 4/1A). This is the case, e.g., in the brush-turkeys *Talegalla* (Fig. 4/2) and the crowned-pigeons *Goura* (Fig. 4/3). The northern and southern taxa usually meet near the south-eastern end of the central mountain range where the northern or the southern form has surrounded the south-eastern tip of New Guinea or both meet there near Milne Bay. In several other cases the representatives are separated by a distributional gap.

The distributional ranges of the three *Talegalla* species inhabiting the Vogelkop region (Red-billed Brush-turkey *T. cuvieri*), northern New Guinea (Brown-collared


MI
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H
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H
8
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H
H
d
9

Fig. 4. Distribution patterns of selected species and subspecies of birds inhabiting the rainforests of the lowlands and lower montane levels in New Guinea, after Stresemann (1936) and Pratt (1982), with additional data. (Legend on page 17)

Brush-turkey *T. jobiensis*) and southern New Guinea (Black-billed Brush-turkey *T. fuscirostris*) are in contact in several areas but do not overlap. *T. cuvieri* and *T. fuscirostris* are in contact at the western end of the Snow Mountains where the former species inhabits the lower montane forests above the range of *T. fuscirostris* (Jones *et al.* 1995:117). In eastern New Guinea, *T. jobiensis* crossed low passes of the central mountain range in a southern direction and here also occurs locally in the lower montane forests above *T. fuscirostris* (Fig. 4/2). Obviously, the presence of *T. fuscirostris* prevents the southward advance of the two northern species into the lowland forests of southern New Guinea. The three *Goura* species replace one another geographically in a similar manner (with restricted hybridisation in the areas where they meet). In other birds where the geographical representatives are considered as subspecies, these taxa hybridise extensively along the contact zones or are assumed to do so.

Geographical variation

The individual and geographic variation of numerous bird species have been analysed for over one hundred years with methods that have become increasingly sophisticated in recent decades. These methods have been adequately reviewed by Selander (1971), Gould & Johnston (1972) and Baker (1985). I emphasise that detailed descriptions of local populations and artificial delimitation of subspecies cannot depict accurately the complex patterns of geographical variation in many wide-ranging species on continents. With sufficient specimen material available over a large area, computers can analyse regional trends statistically, and can generate isolines, contour maps, and trend-surface maps. In this way, regional patterns of character variation may be documented and analysed quantitatively, without *a priori* reference to subspecies

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Legend to Fig. 4

Solid – mountains over 1000 m elevation. **1A–C** Areas of endemism (open double arrows) as distribution centres of endemic species and subspecies (V Vogelkop, MI Mamberano–Idenburg region, SR Sepik–Ramu region, SW south-western lowland region, SE south-eastern lowland region). **1A** Contact south of Geelvink Bay between endemic forms of the Vogelkop, the northern and southern lowlands; **1B** Vogelkop and *southern* lowlands are inhabited by the same form (or group of subspecies) which established contact with the northern form at Geelvink Bay; **1C** Vogelkop and *northern* lowlands are inhabited by the same form (or group of subspecies) which established contact with the southern form also at Geelvink Bay. Either the northern or the southern form extended its range around the south-eastern tip of New Guinea or both established contact near the tip itself (Milne Bay), e.g. map no. 3.

Symbols: A – geographical exclusion without hybridisation; H – hybridisation along the contact zone; stippled area – endemic form of the Vogelkop; dashed and hatched vertically – forms of the southern lowlands and, in some cases, of the Vogelkop; dashed horizontally – forms of the northern lowlands and, in some cases, of the Vogelkop.

Examples shown are: **2** *Talegalla*; note the occurrence of *T. cuvieri* on the southern slope of the Snow Mountains (two open circles) and of *T. jobiensis* on the southern slopes of the Central Mountains (x), **3** *Goura*, **4** *Lorius*, **5** *Psittaculirostris*, **6** *Micropsitta*, g *M. geelvinkiana*, m *M. meeki*, **7** *Geoffroyus*, **8** *Cicinnurus*, **9** *Paradisaea*, r *P. rubra*, d *P. decora*. For further details see text and Table 2.

TABLE 2

Characteristic species and subspecies of birds inhabiting the rainforests of the tropical lowlands and lower montane levels in New Guinea. Arrows indicate range extension. Numbers refer to the corresponding distribution maps in Figure 4.

	South	North-west	North	
	(Fly River Platform)	(Vogelkop)	Mamberano–Idenburg	Sepik–Ramu
Megapodiidae	(2) *Talegalla fuscirostris* →	← *T. cuvieri* →	←	*T. jobiensis*
Columbidae	*Ptilinopus p. pulchellus*	→	←	*P. p. decorus*
	Ducula p. pinon	→	←	*D. p. jobiensis*
	(3) *Goura scheepmakeri* →	← *G. cristata* →	←	*G. victoria*
Psittacidae	*Chalcopsitta scintillata* →	← *C. atra* →	←	*C. duivenbodei*
	(4) *Lorius l. lory*–group	→	←	*L. l. jobiensis*–group
	(5) *Psittaculirostris desmarestii*[1]	→	← *P. salvadorii* →	← *P. edwardsii*
	(6) *Micropsitta keiensis*	→	←	*M. pusio*
	Probosciger a. aterrimus–group	→	←	*P. a. stenolophus*
	(7) *G. g. aruensis*–group	*Geoffroyus geoffroyi pucherani*–group		
Acanthizidae	*Gerygone p. palpebrosa*–group	→	←	*G. p. wahnesi*
Myiagridae	*Arses t. telescophthalmus*–group	→	←	*A. t. insularis*
Paradisaeidae	(8) *Cicinnurus r. regius*–group	→	←	*C. r. coccineifrons*–group
	(9) *Paradisaea apoda* + *P. raggiana* →	←	*Paradisaea minor*	
Meliphagidae	*Philemon n. novaeguineae*	→	←	*P. n. jobiensis*
Dicaeidae	*Melanocharis n. nigra*–group	→	←	*M. n. unicolor*
Campephagidae	*L. leucomela* →	←	*Lalage atrovirens*	
Orthonychidae	*E. c. nigricrissus* →	←	*Eupetes c. caeruleus*–group	

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[1] This species is composed of 2 subspecies on the west Papuan islands and 4 subspecies in western and southern New Guinea (in Fig. 4/5 stippled *desmaresti* + *intermedia*, hatched vertically *godmani*, dashed vertically *cervicalis*).

names (Haffer & Fitzpatrick 1985). Additional museum and field studies of intraspecific variation in birds are needed in order to document regional character changes along clines, across contact zones, and across various ecological gradients within the tropics.

The subspecies concept is most useful where applied to discrete, differentiated populations that are separated by distributional gaps like those found on islands. Within continuous populations inhabiting continental areas subspecies should be distinguished in only two situations: (1) at the ends of steep clines, if the two terminal populations show uniformity over a substantial portion of their ranges, and (2) where two or more wide-ranging populations show different, but in each case fairly uniform, character expression ('plateaus' on contour maps) connected by relatively narrow zones of character change.

Many examples of geographic variation in birds have been discussed by Mayr (1942, 1963), Zink & Remsen (1986) and, with particular reference to Palearctic birds, Voous (1947, 1949, 1950, 1953a,b) and Vaurie (1953–1964).

Arctic migrants

A recent example of an extensive quantitative study of the geographical variation of northern waders is the work of Engelmoer & Roselaar (1998) undertaken in the context of conservation work. Many wader species migrate in huge flocks along the East Atlantic flyway. For conservation purposes, it is important to determine approximately the composition of these flocks in relation to the different geographical origin of the breeding birds. Most of them congregate after breeding over widely dispersed areas in remote boreal and arctic regions as far apart as Greenland and the tundra of eastern Siberia where it is difficult to obtain population estimates. As long as morphometric and colour differences among breeding populations of the various species exist, quantitative estimates of the composition of migrating and wintering flocks are now possible based on a computer program ('Poscon') which determines the *pos*terior probabilities and *con*fidence intervals for a particular bird to belong to one of the differing breeding populations of its species. Based on their study of nearly 5,000 specimens in many museums, the authors analysed on a very thorough statistical basis the geographic variation of the breeding populations of 15 wader species of the Northern Hemisphere to provide a sound database for the continuing conservation effort with migrating and wintering wader populations in western Europe and in other parts of the world. Geographical variation is studied on the basis of standard measurements (lengths of wing, culmen, tarsus, tail, selected primary feathers, etc.) and scoring of the geographically variable colour of certain portions of the plumage like uppertail-coverts and axillaries in some species. The birds include such common migrants as Ringed Plover *Charadrius hiaticula*, Red Knot *Calidris canutus*, Sanderling *C. alba*, Dunlin *C. alpina*, Whimbrel *Numenius phaeopus*, Curlew *N. arquata*, Redshank *Tringa totanus* and Ruddy Turnstone *Arenaria interpres*.

Character geography within species groups

Comparative studies of the species and subspecies of a large genus or of a family permit historical and ecological analyses of various character states such as colour patterns, size, relative tail length and shape of tail, bill size and shape, voice, nests, nesting habits and their functional adaptations. Examples of such comparative evolutionary studies (of which many more are required) are those of Mayr & Moynihan (1946) on the flycatching Rufous Fantail *Rhipidura rufifrons* group in the Malay Archipelago and the Papuan region, and of Mayr & Amadon (1947) on the species of flowerpeckers, Dicaeidae, in these same regions. A similar analysis of the 20 species of drongo, Dicruridae, distributed in South-East Asia and the Malay Archipelago revealed that the characters of the more specialised species, such as large size, frontal crests, long tails, and modifications of the outermost tail feathers, have arisen independently in different branches of the family. Every character varies geographically and is correlated with such features of the environment as temperature and humidity. Double invasions of the same parental stock have led either to the existence of two sympatric species or to the formation of hybrid flocks (Mayr & Vaurie 1948:264-265). Snow (1954) published a similar treatment of trends in geographical variation in Palearctic members of the tits *Parus*. Other evolutionary trends among related allopatric species of the Neotropical Region are the increasing length of the central tail feathers in *Chiroxiphia* and of the uppertail-coverts in *Pharomachrus*.

Studies of the relations between wing and tail length in several groups of closely related species revealed certain trends whose functional interpretation is still open. In the series Brambling *Fringilla montifringilla*–European Chaffinch *F. c. coelebs* group–Chaffinch of NW Africa *F. c. spodiogenys* group–Canary Island Chaffinch *F. c. canariensis* [= *tintillon*] group, tail length increases as the wing becomes shorter and more rounded (Eck 1975). Tail length is only 70% of wing length in the Brambling and increases to 83% in the *F. c. canariensis* group. The underlying selection pressures may be linked to long-distance migration and 'island effect' (Grant 1979). With respect to size, the Blue Chaffinch *F. teydea* of pine forests in the mountains of Tenerife and Gran Canaria is an isometrically enlarged European Chaffinch. Wing and tail length decrease in the subspecies of the Sombre Tit *Parus lugubris* from the Balkan Peninusula east to northern Iran. Because small Père David's Tit *P. davidi* of south-western China, with bright cinnamon underparts, continues this trend of decrease in size, Eck (1980, 1988) considered this geographically isolated species as a representative and close relative of the western *P. lugubris*, pointing out that the plumage colour in *P. (l.) hyrcanus* of northern Iran (underparts tinged rusty) is somewhat intermediate. The Great Tits of the *Parus major* complex have a wing length of approximately 65–80 mm; the tail is relatively longer and more graduated in the *bokharensis* group of Middle Asia than in the other subspecies groups (Eck 1977).

Geographical variation in sexual dimorphism

In several species of birds females show stronger geographical variation than males ('heterogynism': Hellmayr 1929). This has been observed in South American antbirds, Thamnophilidae, in which the males have a non-variable black plumage while the colouration of the females is geographically variable shades of brown. Other examples of heterogynism are White-shouldered Fairywren *Malurus alboscapulatus* (Mayr & Rand 1935) and Sulawesi Cuckooshrike *Malurus alboscapulatus* (Mayr & Rand 1935) and Moluccan Greybird *Coracina morio* (Stresemann 1939). It remains unknown how widespread heterogynism is among birds.

A related topic is the geographically varying degree of sexual dimorphism. On small oceanic islands, some birds show reduced conspicuousness and sexual dimorphism compared with their mainland relatives, probably because there are fewer species on the islands and the problems of species recognition are reduced, resulting in a reduction of sexual dimorphism. A latitudinal gradient of sexual dimorphism involves the New World warblers, Parulidae, and New World orioles, Icteridae. Tropical species tend to be sexually monomorphic and conspicuous, whereas north temperate species tend to be sexually dimorphic (Hamilton 1961). Nesting habits also influence the degree of sexual dimorphism. The females of hole-nesting birds, such as rollers, kingfishers and parrots, are frequently as colourful as their males, because they need no protection through adaptive (camouflage) colouration while sitting on the nest.

Three particularly conspicuous examples of geographical variation in sexual dimorphism are the highly polytypic Golden Whistler *Pachycephala pectoralis* of the Malay Archipelago, Papuan and Australian regions (Mayr 1932, Galbraith 1956), Scarlet Robin *Petroica multicolor* of the islands in the south-western Pacific Ocean (Mayr 1942:48) and the *Pomarea* 'flycatchers' of the Marquesas Islands (Murphy 1938). A genetic drift hypothesis may account for the origin of geographic variation in sexual dimorphism in birds (Peterson 1996).

Geographical variation in polymorphism

In most polymorphic species with discontinuous colour phases there is no evidence for selective mating or any other advantage of the morphs (Mayr 1942:75). In some instances polymorphism varies geographically, the percentages of morphs in the populations changing over large distances, e.g. in the Pacific Reef-heron *Egretta sacra*, Grey Goshawk *Accipiter novaehollandiae* and Papuan Lorikeet *Charmosyna papou* (reviewed by Huxley 1955). In some cases, geographical gradients in polymorphism may be linked to hybridisation along secondary contact zones of previously separated (monomorphic) populations. Subsequent regional introgression may have led to the development of polymorphism, e.g. in the Black Bulbul *Hypsipetes leucocephalus* (Mayr 1941, 1942:83) and in two pairs of wheatear species, Black-eared Wheatear *Oenanthe hispanica*/Pied Wheatear *O. pleschanka* (Haffer 1977) and Variable Wheatear *O. picata*/*O. opistholeuca* (Panov 1992). Huxley's conclusion is still valid: 'The time seems ripe for a detailed survey of the incidence of colour- and pattern-morphism in birds'.

Conceptual contributions of systematists

Conceptual contributions of systematists to the biological sciences through their museum studies of animal collections include the theory of geographical speciation, the principle of population thinking and the interpretation of the gradualness of evolution (Mayr 1973, 1980). These topics will be briefly discussed below.

Geographical speciation

Beginning with Leopold von Buch, Charles Darwin and Alfred R. Wallace during the first half of the nineteenth century a steadily growing number of systematists advocated the theory of geographical speciation from small isolated populations. This theory combines two seemingly incompatible aspects, namely (1) gradual evolutionary differentiation of a separated population and (2) the existence of bridgeless gaps between coexisting species after the completion of isolating mechanisms (Mayr 1942, 1963). The zoogeographical phenomena discussed above, like areas of endemism and the occurrence of contact zones in Amazonia and in other regions of the world, may be interpreted in terms of the theory of geographical speciation. Repeated climatic–vegetational fluctuations during the last several million years probably led to the fragmentation and differentiation of the vegetation zones and their contained faunas, leading to the development of areas of endemism. As climatic conditions changed, the more or less separated faunas were rejoined, leading to the overlap and sympatry of ecologically fully compatible species and to the formation of the contact zones between representative taxa which had reached various intermediate stages of the speciation process during their geographical separation (Mayr 1942, 1963, Haffer 1974, 1997, Haffer & Prance 2001).

Population thinking

Ornithologists of the mid-nineteenth century discovered, when collecting 'series' (population samples) of specimens of one species from certain localities and from different regions, that no two specimens were ever completely alike. These are the phenomena of individual and geographical variation, respectively. For example, H. Schlegel in the Netherlands and J. H. Blasius in Germany, as well as the ornithologists around S. F. Baird of the Smithsonian Institution in Washington, D.C., made great efforts to assemble, from the 1850s to the 1880s, series of specimens of each species to determine the range of variation, publishing detailed lists of all birds examined with information on sex, locality, measurements and colour characters. These workers emphasised the occurrence of individual variation of local populations and of geographically representative forms (subspecies) delineating polytypic species. Many of these and other ornithologists studied variation even though they held typological (essentialistic) views, assuming that an internal type or essence maintains the integrity of each constant species and that variation is no more than an imperfect manifestation of its eternal type.

However, the studies of the ornithologists mentioned above prepared the ground for the development of 'population thinking' (Mayr 1959, 1982:46). Under this evolutionary principle individual and geographical variation are real and represent important phenomena of the natural world. Geographical variation of isolated populations may transcend species limits and lead to the origin of new species. Species possess no eternal integrity, and types in the sense of essentialism are abstractions. Basic concepts like natural selection acting on populations composed of varying individuals are meaningless for typologists. The replacement of typological thinking by population thinking through the research of museum workers is perhaps the greatest conceptual revolution that has taken place in biology. From systematics it was brought into genetics by researchers who had either been trained as systematists or had worked closely with systematists (Mayr 1963:5, 1973).

Gradualness of evolution

During the early twentieth century, museum systematists endeavoured to demonstrate, through detailed analyses of geographic variation of numerous species, that evolution proceeds gradually, as Darwin had postulated, rather than through 'saltations' (jumps), as the Mendelists assumed during that time. Rensch (1929) showed that all species characters vary geographically and that extreme geographical subspecies may differ morphologically more from one another than many good sympatric species. This observation made the interpretation of gradual evolution much more probable than a saltational course of microevolution.

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Development and uses of avian skeleton collections

by Storrs L. Olson

SUMMARY

The importance of skeletal material in systematic studies of birds was recognised by only a few nineteenth-century workers yet osteology has been pivotal in the development of phylogenies and classifications of birds and often provides critical clues in problematic cases. In morphometric studies, skeletal material yields far more, and more accurate, measurements and ratios than obtainable from study skins. Skeletons are essential for the identification of fossils, bones from archaeological sites and food items taken by predatory animals, as well as being useful in physiological and histological studies. Although world skeletal inventories have greatly aided researchers, they also reveal serious deficiencies in museum holdings. The need for more material of avian skeletons is undiminished.

Introduction

Systematic studies in the various branches of vertebrate zoology differ fundamentally according to differences in traditional methods of specimen preparation. In cold-blooded vertebrates (fish, amphibians and reptiles) the entire organism is preserved intact in fluid, ultimately usually alcohol, in which colours often change. Thus, in differentiating lower-level taxa there is a heavy emphasis on meristic characters such as number and distribution of spines, fin rays, and especially scales. In birds and mammals the fundamental systematic unit has traditionally been the museum study skin in which the stuffed, dried integument is preserved, with colouration often playing a greater role in systematic decisions than is the case for poikilotherms.

In the preparation of a traditional mammal study skin, only some of the bones of the foot are left in the skin, so that the skinned carcass contains the virtually complete skeleton. Despite this, mammalogists have in the past been scandalously remiss in preserving skeletal material, apart from the skull and mandible, which are saved as part of the skin specimen and which receive equal or greater consideration in systematics. Consequently there is a heavy emphasis on cranial characters, particularly dentition, in mammalogy.

Modern birds, of course, have no dentition, and in the traditional museum study skin most of the skull and bones of the wings, legs and tail are left in the skin. The resulting skinned carcass therefore contains only the bones of most of the vertebral column, pectoral girdle, pelvis and femora, along with all of the viscera, tongue and trachea. After the sex has been determined, this body or trunk carcass is usually discarded. Therefore the process of specimen preparation in ornithology has sometimes been described as peeling off the wrapper and throwing the bird away. Diagnoses of new species and subspecies of birds have been heavily dependent upon plumage colouration and pattern, wing formulae, and the shape and proportions of the wing and tail, so that the ornithologist is far more dependent on feathers than the mammalogist is upon fur.

For a while, the sternum of birds, because it could be easily extracted from the skinned carcass, had a certain vogue as an object of study. Early skeletal collections often contained a high proportion of these sterna, usually with the coracoids and scapulae still attached, and sometimes one may encounter an old skin in collections that still has the sternum tied to the legs or label. Comparative morphology of the sternum occupied the attention of several French ornithologists, and probably reached its zenith with L'Herminier's (1827) classification of birds based on the morphology of the sternum.

Nevertheless, this osteological diversion did little to further the development of avian skeletal collections. The description of new species and subspecies was the principal activity of museum ornithologists during all of the nineteenth and most of the twentieth centuries, and the study skin was the coin of the realm. As traditionally practised, preparation of a complete skeleton meant sacrificing the skin, and field collectors were extremely reluctant to bring back other than well-made study skins, a reluctance that continued through at least to the 1950s. As an example, in his long and distinguished career at the Smithsonian, Alexander Wetmore collected over 27,500 specimens, nearly 14,500 in Panama alone. Despite the fact that Wetmore was active in avian palaeontology, regularly used the Smithsonian skeleton collection, and was instrumental in the Institution's purchase of large and important collections of skeletons, virtually all of the specimens he collected himself were prepared as skins only. The two decades when he was most active in the field marked the period of slowest growth in the Smithsonian skeleton collection in the twentieth century (C. Ludwig, Smithsonian computer files).

History

Serious examination of the avian skeleton can be traced back to the sixteenth century with Belon's (1555) classic comparison of the skeleton of a raven (Fig. 1) with that of *Homo sapiens*. Centuries would pass before the study was taken up again.

Bird skeletons and fluid-preserved specimens were of particular interest to the British ornithologists William Jardine and Thomas Eyton. The correspondence of the celebrated John Gould (Sauer 1998–2001) contains numerous exchanges between these three gentlemen regarding the acquisition of such specimens, and Gould himself took care to obtain anatomical specimens of birds for his colleagues during his own explorations of Australia. Eyton's researches are epitomised by his *Osteologia Avium* (1867–1875).

At the same time in France, Alphonse Milne-Edwards produced his monumental work on the fossil birds of France (1867–1871) in which there are many comparisons with (and illustrations of) the comparative osteology of modern birds. Likewise, skeletal anatomy received considerable attention in his classic work, with Grandidier, on the avifauna of Madagascar, in which the skeletons of many different taxa were illustrated (Milne-Edwards & Grandidier 1876–1881). At least some of Milne-Edwards's collection still exists at the Paris Museum, although I am told that this material was discovered being stored in an alleyway.

German researchers also investigated the relationships of birds through studies of anatomy, including osteology, which culminated in the exhaustive treatise of Max Fürbringer (1888), whose results were adopted by Hans Gadow (and later Alexander Wetmore) to produce the flawed and derivative—but extremely familiar—system of classification of the orders of birds that dominated ornithological literature throughout the twentieth century.

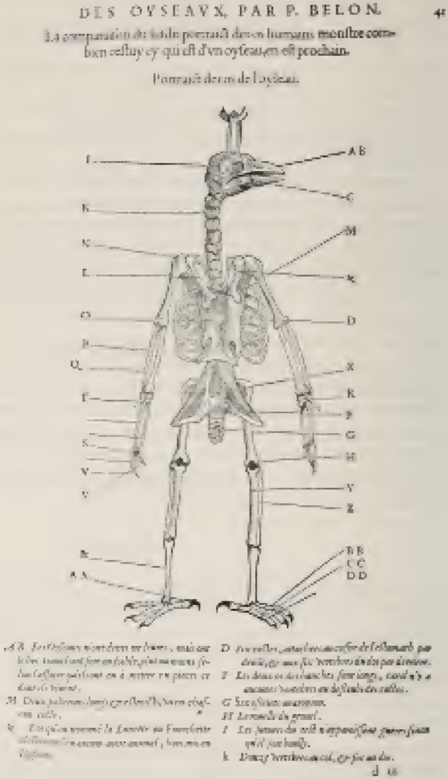
DES OYSEAVX, PAR P. BELON.

Fig. 1. Skeleton of a Common Raven *Corvus corax*, by Belon (1555). Set next to that of a human skeleton, this was the first detailed illustration of an avian skeleton. © The Natural History Museum, London.

Comparative anatomy had, of course, long been an important zoological tool and was the subject of intensive research by Baron Cuvier in Paris and later by Richard Owen in England. The field received a tremendous boost after 1859, when Charles Darwin's evolutionary theories provided a rationale for similarities and differences in anatomical structures. The discipline of comparative anatomy was formalised in some museums by the creation of separate departments. The avian skeletal collections in several museums, such as the Smithsonian Institution, Field Museum of Natural History in Chicago, and the Natural History Museum in the U.K., have as their nuclei the specimens inherited from now-defunct departments of comparative anatomy, or from medical museums such as the former museum of the

Royal College of Surgeons in Britain and the U.S. Army Medical Museum in Washington.

Uses

Osteology played a pivotal role in the development of phylogenies and classifications of birds, and may still provide critical clues for determining the true relationships of taxa that have long been misplaced. For example, skeletal characters were of paramount importance in showing that the Australian Plainswanderer *Pedionomus torquatus* belongs in the Charadriiformes and not near the Turnicidae in the Gruiformes (Olson & Steadman 1981). Osteological characters were among the many lines of evidence adduced to place flamingos with the Charadriiformes rather than with storks or ducks (Olson & Feduccia 1980). Even single osteological characters, such as fusion of the phalanges of the inner toe in certain genera of Accipitridae (Olson 1982), can provide very suggestive clues as to relationships within a particular group.

Osteology has figured importantly in recent revisionary studies of birds, by using character analyses that supposedly conform with the principles of 'phylogenetic systematics' (e.g. Livezey 1996, 1998), although the results may be viewed as mixed (e.g. Sorensen *et al.* 1999). Prior to this, the rise of phenetics, or numerical taxonomy, in systematics led to a flurry of activity in avian skeletal collections (e.g. Schnell 1970). Although this school waned and phenetics is no longer 'politically correct' in the world of systematics, its temporary ascendancy did result in increased growth of avian skeletal collections and in the emergence of several institutions as major resources of skeletal material. These may not have achieved their present importance had they not had the initial boost provided by the former interest in phenetics.

In the traditional bird study skin, relatively few useful standard measurements can be taken. Furthermore, these measurements can be very difficult to replicate, in part because they may be affected by the state of moult and degree of wear of feathers, or even of wear of the ramphotheca. On the other hand, for morphometric studies the avian skeleton provides many more possible measurements and ratios, which are also much more easily and accurately replicated. Phenetics and morphometrics were certainly factors in the phenomenal growth of the avian skeletal collection at the Royal Ontario Museum, which grew from 1,100 specimens in 1965 to some 48,000 at present (J. Barlow pers. comm.). Large series of skeletons provide a sound basis for assessing geographic size variation within a species. A classic example of this is the study by Rising (1987) of sexual dimorphism in skeletons of Savannah Sparrow *Passerculus sandwichensis*, in which 24 different measurements were taken from 1,791 individuals from 51 populations. For similar studies to be possible, however, much more collecting of specimens would be necessary.

In the investigations mentioned above, the skeletons themselves are the objects of study and the scientific results obtained are taken directly from museum skeletal collections. However, in the most intensive modern use of skeletal collections of birds, the skeletons, although of critical importance, are secondary and the objects of study are unidentified bird bones that must be compared with skeletons of known identity.

Although it may not be widely appreciated, there are in fact numerous sources of unidentified bird bones. Fossils of all ages are of primary importance for their evolutionary information. In numbers, these would be followed by material from archaeological sites. Skeleton collections are likewise essential for studies of the food remains of predatory birds and mammals; skeletons have been used as indices of body size, and in physiological or histological studies such as those charting changes in bone structure (the Haversian system), or where attempts have been made to age birds using cross sections of long bones.

Other uses of skeletal collections include exhibitions, teaching scientific illustration, other projects which fall into the category of 'art', and various commercial ventures such as use in advertisements. Avian skeletal collections also play an important role in teaching zoology, and, as would be expected, collections associated with universities tend to have had an intensive and consistent use for teaching, whereas other collections tend to have been little used for such purposes. Skeletons are also used to identify birds involved in airplane strikes (although most such identifications are based on feathers), as well as in various forensic applications, such as the identification of carcasses of illegally taken birds or, in rare cases, bird bones that have been taken as evidence in other crimes.

Fossils

In the past quarter century, there has been tremendous growth in the study of fossil birds from all time periods—witness the number of papers, and broad range of subjects, treated in the volumes which emanated from the first four meetings of the Society of Avian Paleontology and Evolution (Mourer-Chauviré 1987, Campbell 1992, Peters 1995, Olson 1999) and two earlier festschrifts (Olson 1976, Campbell 1980). The diagnosis and description of new species is still one of the main activities of avian palaeontologists, and in their work the skeleton has primacy over the study skin. The need for adequate comparative material for identifying fossils has been one of the prime factors in driving the growth of avian skeleton collections. Notable among these are the collection of Pierce Brodkorb (now incorporated in the Florida Museum of Natural History) and those assembled mainly by Evegeny Kurochkin and at the Palaeontological Institute of the Russian Academy of Sciences in Moscow, and by Zygmunt Bochenski at the Polish Academy of Sciences in Krakow.

A good example of how palaeontological studies have spurred the growth of skeletal collections comes from the Caribbean island of Puerto Rico. Alexander Wetmore collected extensively in Puerto Rico and wrote the definitive studies of its avifauna (Wetmore 1916, 1917). Consequently, the Smithsonian collections of Puerto Rican birds were once, for skins, probably the largest and most important in the world. However, when I returned from Puerto Rico in 1976 with tens of thousands of fossil bird bones from cave deposits on the island, I could find only four skeletons, from three species of bird from Puerto Rico, in the Smithsonian collections. Because this was utterly insufficient for researching the fossil avifaunas, a new campaign of collecting modern comparative material had to be initiated on Puerto Rico and elsewhere in the Antilles. The Smithsonian collections now hold nearly 4,000 skeletons from throughout the West Indies. Well over 90% of these have been collected since 1975, and almost entirely because of their need in palaeontological studies.

The development of modern collections

Although by far the majority of skeletal specimens consist of dry bones in varying degrees of disarticulation, a small number are prepared as cleared and stained specimens in which the soft tissues are rendered more or less translucent and the bones and cartilage are dyed different colours. This essentially involves converting an intact fluid-preserved specimen into a skeletal specimen, although the skeleton is still maintained thereafter in fluid. Cleared and stained specimens have been important in studies of growth and development (Olson 1973, Burke & Feduccia 1997) and in as yet unpublished studies of the systematics of hummingbirds (R. L. Zusi in prep.).

Moreover, it must not be forgotten that, because study skins still contain many of the more diagnostic bones of the avian skeleton, skin collections may become a major source of skeletal material. This is especially useful for extinct species for which no skeletons were ever saved. Methods have been developed where the skull and limb bones can be carefully removed from skins with little or no loss of the scientific value of the study skin itself, yet allowing great gains in knowledge of osteology and even myology (Olson *et al.* 1987). Without such bones extracted from skin collections, the study of the fossil avifauna of the Hawaiian Islands, for example, would have been significantly impeded (James & Olson 1991, Olson & James 1991). Perhaps the best example of the use of this method was the extraction of the skull from the unique holotype of the Lanai Hookbill *Dysmorodrepanis munroi*, after which this was once again classed as a valid genus and species rather than as an aberrant individual of another species (James *et al.* 1989).

Another source of skeletal data from skin specimens is from x-rays, which have been used for determining age in songbirds (Rasmussen 1998) as well as for trying to determine the origins of particular specimens such those of as rare Hawaiian specimens (Olson 1996) or those with fraudulent data (Rasmussen & Collar 1999, Rasmussen & Prŷs-Jones 2003, this volume).

Although specific research projects have added significantly to world holdings of avian skeletons, the growth of skeletal collections has mainly resulted from general collecting in which some of the specimens acquired are chosen for preservation as skeletons. There is now a generally prevalent modern outlook, or ethic, of specimen preparation in museums, that dictates that not all specimens should be made up as study skins and that some balance must be struck between the need for skins, skeletons and fluid-preserved specimens. Concurrent with this shift has been the emergence of an ethic of attempting to obtain maximal information, at least from specimens of scarcer species. This in turn has given rise to creative new methods of specimen preparation that allow for preservation of skin, skeleton and soft parts in different states of completeness, along with tissue samples for biochemical studies.

Another very positive development has been the appearance of world skeletal inventories (Wood *et al.* 1982, Wood & Schnell 1986), which have provided a great stimulant to the enhancement of skeletal collections. These inventories have provided a rather shocking picture of just how deficient the museum collections of the world are in species represented by non-skin preparations. Field collectors have been able to consult these inventories prior to or during expeditions to determine where gaps in holdings could be filled. Knowing in the field that no osteological material exists for a given species has more than once provided the incentive for preparing a specimen as a skeleton rather than a skin.

Nevertheless, I have detected a few hints of a slight backlash regarding skeletal preparation among those I solicited for information. One collections manager considered that the strong reputation of the skeleton collection at his institution had caused specimens to be prepared as skeletons that should have been made as skins or alcoholics. At another museum, concern was expressed that far less use was being made of the skeleton collection, compared with tissues or skins, which called into question the value of expending so much effort on skeletal preparation. Nevertheless, it is clear that a much healthier balance now exists in most major museums in regard to manner of specimen preparation.

Recognition must be made of the fact that, in North America, increased emphasis on skeletal preparations and the importance of skeletal specimens is in great measure due to the influence of the staff of four museums associated with large universities: Michigan, Kansas, Florida and California (Berkeley). Each of these museums houses large and important collections of bird skeletons and each has a long history of active involvement in avian palaeontology and systematics. There are few ornithologists in North America who regularly use skeletal specimens in their research, or who are now directly responsible for the curation of skeletal collections, who did not receive training at or were not in some other way directly influenced by these four research institutions.

The extent to which individual scientists or collectors have influenced the growth of skeletal collections varies from institution to institution. Some important collections have been formed almost single-handedly, whereas others are the cumulative result of generations of effort by staff, students and associates. Conversely, individual influence has at times slowed collection growth, as when a curator has no interest in studies involving osteology and neither acquires nor prepares skeletal specimens. Archaeological departments in museums and universities, particularly in Europe, have been responsible for developing numerous smaller collections of avian skeletons for use in identifying bone remains from archaeological sites.

Despite these advances, it is a depressing fact that active field collecting of birds is on the wane, being greatly hampered by misplaced sentimentalities and bureaucratic impediments. This comes at a time when there still exist many critical deficiencies in world museum holdings and when habitats, along with their birds, are being destroyed.

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Author's note: This essay was developed as a preliminary draft that was intended to be circulated rather widely for comments from curators and users of skeletal collections so that other perspectives might be incorporated. It was first submitted for remarks on format and suggestions that might enable better conformity with other papers in the symposium; but as no more was heard on the subject I did nothing further with it. When it resurfaced three years later, I was asked to allow it to be included, which I have done reluctantly, making only very minor changes. I take no responsibility for the fact that the result is neither current nor particularly well balanced.

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Avian spirit collections: attitudes, importance and prospects

by Bradley C. Livezey

SUMMARY

Spirit (fluid-preserved) specimens of birds play a special role in anatomical and systematic studies. A literature review and survey of natural history museums reveals that spirit collections of birds have undergone a modest, steady increase to compose roughly 2–3% of specimens worldwide. However, many problems of representation indicated by the *Global inventory* (Wood *et al.* 1982a) persist, and current users of spirit specimens often encounter additional problems over preservation, provenance and associated data. Consensus exists that spirit specimens are informative for phylogenetic investigations and are the key source of data regarding functional morphology, that the primary motivation for preserving specimens in spirit is to retain maximal information for future investigators, and that expertise deriving from the study of anatomical specimens is at greatest risk in specimen-based ornithology. Nevertheless, bias persists for the preparation of bird specimens as study skins, evidently in response to demand by visitors (including artists) to collections, to a high threshold of perceived sufficiency in skin series, and to a parochial perspective on the availability of taxa as study skins. Curatorial concerns over preparation, storage and study of spirit specimens are evident but generally exert little influence over allocational priorities. Recommendations and justifications regarding the preservation of bird specimens in spirit are given.

Introduction: spirit specimens in ornithological research

Systematic ornithologists work within a subdiscipline dominated increasingly by molecular methods (Avise 1996), despite the absence of an empirical justification for such a change in analytical priorities (Hillis 1987, Crowe 1988, Swofford 1991, Eernisse & Kluge 1993, Novacek 1994, Wiens & Hillis 1996, Lee 1997, Wheeler 1997). Nonetheless, preserved specimens of birds remain an important resource for many types of study, including those based on DNA (McKitrick 1981, Olson 1981, Finley 1987, Houde & Braun 1988; *contra* Ricklefs 1980, Ricklefs & Gill 1980). Given the enduring importance of morphological characters in modern systematics regardless of taxon (Sanderson *et al.* 1993), the relevance of museum collections of birds is not unexpected, and the view of natural history collections as invaluable archives has become increasingly appreciated (Cotterill 1997, Murariu 1997).

Spirit specimens of birds—also referred to as wet anatomical or fluid-preserved specimens—play a special role in a diversity of anatomical and systematic studies (Quay 1974, Raikow 1985). Essentially, any ornithological investigation that is based in part on aspects of the anatomy of birds exclusive of the integument or skeleton (i.e. soft internal tissues) requires samples of fluid-preserved specimens (these can involve whole birds, parts, stomachs and contents, tongues, chicks and even unhatched embryos, which are hard to preserve any other way), and moreover many osteological features are interpretable only through study of the overlying musculature and ligaments or the internal organs, including the digestive apparatus and stomach contents (Baumel *et al.* 1993). Recent works incorporating information based on dissections of birds include descriptions of the musculature (e.g. Schreiweis 1982, Zusi & Bentz 1984, Homberger 1986, Raikow 1993, Weber 1996, Müller & Weber 1998), functional analyses (e.g. Zusi 1962, Livezey 1990, 1992a,b), studies related to pathology (e.g. Cooper *et al.* 1998), phylogenetic reconstructions based on morphological characters (e.g. Raikow 1978, 1987, Prum 1990, 1992, McKitrick 1991a,b, Livezey 1997, 1998), feeding ecology (e.g. Arizmendi & Ornelas 1990) and even shapes of birds (e.g. Hayman 1986).

However, despite the unique utility of spirit specimens for many aspects of ornithological research (for example moult, locomotion, feeding, display and systematics), such material remains comparatively rare in museum collections (Peters 1933, Wood *et al.* 1982a,b, Zusi *et al.* 1982, Wood & Schnell 1986, Raikow 1985). A number of surveys of ornithological collections have documented that spirit specimens are less abundant than skeletons and much less abundant than traditional skin specimens (Banks *et al.* 1973, Clench *et al.* 1976). Raikow (1985: 119) noted that the survey by Banks *et al.* (1973) revealed that museums in North America hold '…over 4 million avian study skins, but only 142,150 skeletons, and a bare 52,025 spirit specimens'. This observation indicates that the ratio of the three major classes of specimen in the survey by Banks *et al.* (1973) approximated 77 skins: 3 skeletons: 1 spirit specimen.

A fortuitous outcome of the rarity of anatomical specimens is the publication of inventories of spirit and (to a lesser degree) skeletal specimens in a number of museums (Ames & Stickney 1968, Blandamer & Burton 1979, Gillette & Bartle 1982), an exercise evidently prompted as much by the tractability of holdings as by the priority accorded the specimens themselves. The importance of the manageably small numbers of spirit specimens to the compilation of inventories is reflected by the fact that a global inventory of avian skin specimens remains years away (largely because many skin collections remain uncomputerised), whereas such inventories for skeletal and spirit specimens were completed roughly 15 years ago (Wood *et al.* 1982a,b, Wood & Schnell 1986). A review of such inventories or a personal visit to a natural history collection substantiates a commonly held perception among museum ornithologists: whereas skin specimens generally are available in substantial series in many collections, skeletons and (especially) spirit specimens are much rarer for a given taxon, if available at all (Raikow 1985).

Moreover, investigators often discover that those spirit specimens that are available are often damaged or derive from captive populations or are accompanied by limited or no associated data. Conventional wisdom holds that the disparate proportions and diverse quality of study skins, skeletons and spirit specimens result from a widespread curatorial tradition of allocating wild-taken specimens having detailed associated data to collections of study skins, whereas damaged specimens of captive origin and/or with poor documentation are allocated for preparation as skeletons or spirit specimens (Raikow 1985).

An unfortunate reality of curation is that collections of vertebrates are comparatively costly to acquire and maintain (Blackmore *et al.* 1997). Moreover, the relegation of spirit specimens to a lower priority than that accorded traditional skin specimens or prepared skeletons is to some degree understandable, given several curatorial and investigational characteristics of spirit specimens. First, spirit specimens typically entail the use of formalin for fixation and ethanol for storage; the former is a toxic, unpleasant substance with which to work, and the latter is often legally controlled, can be contaminated by trace amounts of toxic substances (e.g. methanol) and may be combustible under certain circumstances. Second, spirit (fluid-preserved) specimens are often comparatively massive, and their storage can pose special challenges for older museums not designed to meet the associated weight-bearing requirements. Third, fluid-preserved specimens are typically stored in glass containers subject to breakage and, regardless of the quality or nature of the containers used, ethanol is virtually certain to leak from the storage containers over time; such collections therefore require constant monitoring to prevent infection by mould or desiccation of specimens. Fourth, many anatomists consider fluid-preserved specimens to be aesthetically unattractive and difficult to study; moreover, those investigators who are willing to handle spirit specimens must overcome the curatorial hurdles that accompany (reasonably enough) the typically destructive impact of empirical methods usually employed with spirit specimens, a condition exacerbated by the rarity of many taxa in spirit collections. Other concerns about spirit collections include fire risks, sheer cost of glass jars, handling weights, availability of expertise with respect to the use of labels and inks and the sealing of jars, and sheer curation time (confirming, tracking and maintaining data on spirit specimens is, owing to problems with labelling, significantly more complex and time-consuming than equivalent work with skeletons, eggs, mounts or skins).

Consequently, ornithologists seeking spirit specimens for study are faced by considerable limitations in number, substandard quality in much of the scarce material available, and comparatively stringent conditions on access, which in combination often result in a given taxon not being represented, worldwide, by a single suitable fluid-preserved specimen. What is the severity of this problem for modern systematists—is the scarcity of spirit specimens at the outset of the twenty-first century as serious as indicated by the landmark surveys of Peters (1933), Banks *et al.* (1973), Wood *et al.* (1982a,b), Wood & Schnell (1986), and Rogers (1986)? Moreover, what are the priorities of curatorial professionals with respect to the method of preparation and preservation of birds specimens? Finally, what are the likely impacts of current curatorial attitudes on the quality and diversity of avian spirit specimens that will be available for future study?

The objectives of this study were several: (1) to review selected, prevalent opinions bearing on spirit (anatomical) specimens of birds; (2) to summarise historical trends in collections of spirit specimens based on published inventories and a new survey based on questionnaires; (3) to summarise curatorial attitudes regarding spirit specimens based on this same survey; and (4) to discuss the likely impacts of these perspectives, trends and attitudes on avian spirit specimens and the investigations that require them.

Methods

Questionnaire

In the second quarter of 1999, I mailed questionnaires comprising 27 questions (see Appendix), with covering letters, to 50 North American and European institutions having significant ornithological collections. Addresses and curators of these collections were taken from the lists of institutions provided by Wood *et al.* (1982a,b) and Wood & Schnell (1986), as updated by the mailing list used in the unpublished survey conducted by Rogers (1986). By the deadline specified, responses were received from 29 institutions, to which I added my own completed questionnaire for the Carnegie Museum of Natural History. Most of the returned questionnaires were fully completed (all questions answered as instructed); a minority included one or more unanswered questions, but no more than four questions were returned without a response.

Acronyms used for major institutions were as follows: American Museum of Natural History, New York (AMNH), Carnegie Museum of Natural History, Pittsburgh, Pennsylvania (CMNH), U.S. National Museum of Natural History, Washington, D.C. (USNM), Museum of Vertebrate Zoology at the University of California (MVZ), and the Museum of Zoology at the University of Michigan, Ann Arbor (UMMZ).

Protocols for summarising responses

Most of the questions included in the survey consisted of multiple (3–10) alternative responses; typically, the respondents were asked to rank the responses from most appropriate (to be assigned a '1') to least appropriate (to be assigned the largest integer required), and indicating 'ties' by assigning the same integer rank to the responses deemed of equal relevance. As is conventional in such exercises, tied alternatives were all weighted by the median value of the ranks included in the ties. A minority of questions simply asked respondents to indicate without ranking which, if any, of the alternatives listed were applicable in their experience. Finally, a few questions asked for tallies of selected variables for each collection surveyed (e.g. current numbers of specimens by class of preparation).

In the oral presentation of this paper, most of the responses were displayed in summary pie-charts or histograms. Pie-charts were used to display overall preferences indicated for questions requiring ranking of alternative responses; in order to associate the responses receiving highest preference with the largest portion of the pie-chart, the total scores for each alternative were transformed into the inverse proportion of the grand total for the question. Simple counts (unranked) were presented as histograms or tables. In this written account, with considerations of space at a premium, I tabulate the mean scores for questions incorporating information on ranks (highlighting the most favoured alternative in boldface). Simple tallies, as in the oral presentation, are compiled as such. This simplistic approach to summarising the data emphasises only the clearest findings suggested by the comparatively meagre sample of museums, and avoids the over-interpretation of minor differences which cannot be considered robust in what must be regarded as only a preliminary study.

Results

Growth of collections

A summary of tallies of skin, skeletal and spirit specimens of bird based on published surveys (Peters 1933, Banks *et al.* 1973, Wood *et al.* 1982a,b, Wood & Schnell 1986), an unpublished survey by Rogers (1986), and the present survey (questions 19–21) revealed that, despite an enduring, significant predominance of skin specimens in ornithological collections, the proportions of skeletal and spirit specimens have undergone a modest but steady increase (Table 1). Thus the approximate proportions of skin, skeletal and spirit specimens, respectively, changed from 192:2:1 in 1933 to 70:3:1 in 1973 to 34:2:1 in 1986 and to 36:2:1 in 1999. In other words, during 1933–1999, the proportions of the three types of specimen changed as follows: skins declined from > 99% to ~ 93%; skeletons increased from ~1% to ~5%; and spirit specimens increased modestly from <1% to ~ 2%.

These general patterns, however, obscure differences among major museums (Table 2). Although most major collections underwent a primary period of growth during 1933–1973, the proportions of the three major classes of specimen showed different trajectories (Table 2): AMNH showed virtually no growth in collections other than skins until the last decade or so, and this increase emphasised skeletal holdings; ornithological collections at UMMZ, MVZ and CMNH manifested an early plateau in numbers of study skins, with steady increases in skeletal and spirit specimens; and USNM showed essentially uniform increases in all three classes of specimens, although the rate of increase of skin specimens was distinctly, uniformly higher.

TABLE 1

Numbers (%) of avian specimens in major collections by class of specimen and year of survey, based on Peters (1933), Banks *et al.* (1975), Wood & Schnell (1986) plus Rogers (1986), and the present study

	Year of survey (number of institutions sampled)			
Class of specimen	1933 (16)	1973 (29)	1986 (32)	1999 (30)
Skin	1,757,625 (98.7%)	3,363,350 (94.9%)	3,411,786 (91.1%)	4,633,495 (91.7%)
Skeleton	14,654 (0.8%)	132,855 (3.7%)	232,786 (6.2%)	289,903 (5.7%)
Spirit	9,175 (0.5%)	47,785 (1.3%)	101,071 (2.7%)	128,732 (2.5%)
TOTAL	1,781,454	3,543,990	3,745,021	5,052,130

TABLE 2

Numbers of specimens of bird preserved as skins, skeletons and spirit specimens in five major North American collections in four different twentieth-century surveys, based on Peters (1933), Banks *et al.* (1975), Wood & Schnell (1986) plus Rogers (1986), and the present study

Collection	Class of specimen	Year of survey 1933	1973	1986	1999
American Museum of Natural History	Skin	685,000	900,000	900,000	900,000
	Skeleton	—	7,000	12,000	24,000
	Spirit	—	5,000	8,000	10,000
U. S. National Museum of Natural History	Skin	252,000	400,000	480,000	550,000
	Skeleton	12,654	25,000	30,000	51,248
	Spirit	8,875	18,000	20,000	26,784
Carnegie Museum of Natural History	Skin	100,000	150,000	160,000	155,379
	Skeleton	0	2,000	10,500	15,779
	Spirit	0	2,500	5,000	6,756
Univ. California, Museum of Vertebrate Zoology	Skin	59,200	150,000	169,500	160,000
	Skeleton	0	9,000	10,704	20,000
	Spirit	0	1,700	2,497	3,200
University of Michigan, Museum of Zoology	Skin	33,000	200,000	150,000	170,690
	Skeleton	—	11,100	20,000	23,200
	Spirit	—	300	1,300	3,393

Priorities of allocation

The majority of questions put to respondents concerned their perceptions of the use, potential informativeness and curatorial relevance of the various classes of preparations of avian specimens in museum collections. The primary objective of these questions was to gain insight into the motivation behind the critical decisions over the form of preparation or preservation to be allocated to new and important specimens. Limited redundancy of questions was intentional, as a means of confirming any patterns in attitudes that might emerge, and of limiting errors of interpretation stemming from single opportunities to reveal opinions.

Below, I summarise the responses to questions pertaining to the criteria and considerations that relate to allocation of new specimens to skin, skeletal or spirit preparations (Table 3). See the Appendix for full text of questions and alternative responses as provided to respondents.

Question 1.—New, valuable specimens made available for accession as scientific specimens were roughly twice as likely to be prepared as study skins as either skeletal or spirit specimens, the latter two options being approximately equal in preference.

Question 2.—Roughly half of the respondents consult both *Global inventories* (Wood *et al.* 1982a,b, Wood & Schnell 1986) when allocating specimens. Almost as many consult neither, and a small number refer only to the skeletal inventory on a regular basis for allocation of new specimens.

Question 3.—Of the alternative reasons for allocating a specimen for preparation as a study skin, the *popularity* of skin specimens with visitors was the most favoured response. Of the other seven justifications offered, none won a clear designation as second-most preferred.

Question 4.—Of the alternative reasons for allocating a specimen for preparation as a skeleton, the *condition* of the specimen was ranked the most important consideration. Comments by respondents and informal discussions with colleagues indicate that the criterion of 'condition' in this context typically implies that specimens in poor condition (freezer-damaged, spoiled before freezing, poor condition of plumage or incomplete associated data) were more likely to be relegated to the skeleton collection than were specimens in good condition. Of the other seven justifications offered, none won a clear designation as second-most preferred.

TABLE 3

Summary of scores of responses to questionnaire (Appendix); responses to questions in which alternatives were assigned ranks are summarised by the mean ranks reported (entries indicating strongest support are in boldface), whereas responses to questions asking that one or more alternatives be checked if appropriate (marked by *) are summarised as the total number of positive responses received (30 respondents, although some individuals declined to answer one or more questions); numbers of questions not amenable to numerical scores are enclosed by square brackets.

	Summary score by response									
Question	a	b	c	d	e	f	g	h	i	j
1.	**1.3**	2.1	2.6	—	—	—	—	—	—	—
2*.	13	0	4	2	12	—	—	—	—	—
3.	4.6	5.5	5.1	**2.0**	3.7	4.3	4.0	6.9	—	—
4.	3.9	5.1	5.1	3.7	**2.5**	4.9	3.7	7.1	—	—
5.	**1.5**	3.8	5.3	5.1	3.9	5.5	3.9	7.0	—	—
6.	6.1	3.6	**2.2**	4.2	4.7	5.1	**2.1**	—	—	—
7*.	9	5	14	1	1	—	—	—	—	—
8.	5.4	3.6	4.0	5.7	**2.4**	6.2	8.3	6.6	6.0	6.7
9*.	7	3	16	11	3	22	19	—	—	—
10.	2.5	2.9	**2.0**	3.1	3.8	—	—	—	—	—
11.	2.3	1.9	**1.2**	—	—	—	—	—	—	—
12.	**2.2**	2.4	3.0	2.4	—	—	—	—	—	—
13.	3.5	2.8	2.3	**1.3**	—	—	—	—	—	—
14.	2.9	1.9	**1.2**	—	—	—	—	—	—	—
15*	20	18	15	14	14	—	—	—	—	—
16*.	5	7	8	7	4	—	—	—	—	—
17*.	12	4	6	5	0	—	—	—	—	—
18.	**2.3**	2.7	4.3	4.3	**2.4**	5.0	—	—	—	—
[19–21].	—	—	—	—	—	—	—	—	—	—
22*.	1	17	12	—	—	—	—	—	—	—
23*.	9	18	2	—	—	—	—	—	—	—
[24–27].	—	—	—	—	—	—	—	—	—	—

Question 5.—Of the alternative reasons for allocating a specimen for preparation as a spirit specimen, the preservation of *maximal information* was ranked as the most important consideration. As in the corresponding questions for skin and skeletal specimens, none of the other seven justifications offered emerged as the second-most preferred.

Question 6.—Of the reasons perceived to account for the comparative rarity of spirit specimens in ornithological collections, *curatorial traditions* and *low demand* for study were ranked as the most plausible (Table 3).

Question 7.—Of the four cited classes of curatorial staff, or combinations thereof, the ranked responses indicated that the staff member most frequently responsible for allocation of new specimens is the *collection manager*. It should be noted in this context that budgetary limitations in some museums have shifted most or all curatorial duties from curators (if any) to support staff, notably collection managers, and that the importance of collection managers in this critical decision may reflect, in part, the dictates of logistics instead of genuine, administrative preference. Insights into such staffing issues largely derived from responses to questions 24–27 of the survey.

Question 8.—Of the ten alternative justifications for a hypothetical increase in holdings of spirit specimens in the coming years, respondents ranked the *preservation of the entire specimen for posterity* as the most persuasive. Ranks given other options were very close, forming a virtual continuum of scores, and precluded further designation of relative preferences.

Question 9.—Of possible preparations to be applied to an exceptionally rare and valuable specimen, respondents favoured the preservation of the specimens as a *study skin with partial skeleton*; conservation as a skull-less skin ('schmoo') and partial skeleton, or as an entire skin specimen, emerged as second and third preferences, respectively. However, 19 of 22 respondents also indicated an intention to retain, in addition to the various preparations of skins and skeletons, organs in spirit or frozen tissues. Allocations of the hypothetical 'voucher' specimen either as a full skeleton or complete spirit specimen were the least favoured of the alternatives presented.

Question 10.—The primary reason underlying current allocations of new specimens at the institutions of the respondents was the *availability of the taxon in their own collections* (i.e. 'local' representation). This preference was comparatively weakly indicated, however, as the other four alternatives listed received moderately strong support.

Question 22.—Increasingly, combination-preparations of specimens are being used to preserve more and diverse data from valuable specimens of birds. This question revealed that a majority of respondents oversee the preparation of study skins and partial skeletons at least infrequently, although most categorised these efforts as occurring 'rarely' as opposed to 'routinely.' Only a single respondent indicated that such dual preparations were never performed.

Question 23.—In parallel with the preceding question, respondents were polled as to the preparation of a second variation of dual preparation—study skin with partial spirit specimen. In this case, the majority 'rarely' supervised such combinations, with almost one-third indicating that such preparations 'never' occurred; only two respondents characterised such preparations as 'routine'.

Importance of specimens

Several questions were intended to assess the perceptions of respondents concerning the relative importance of study skins, skeletons and spirit specimens for ornithological research. It was hoped that these questions would transcend current practices and patterns of use, and provide insights into underlying motivations, the potential informativeness of specimens and the impact of curatorial trends and current holdings on selected areas of expertise and future research.

Question 11.—Of three areas of anatomical expertise—those pertaining to the externum, skeleton or soft (internal) anatomy—*internal anatomy* was ranked most heavily as the subdiscipline undergoing a decline in recent decades (Table 3); the other two options received substantially less support. Although the majority of respondents implicitly agreed with the presumption that declines in expertise were evident across anatomical systems, the unintended bias reflected in the question may have distorted the responses. It is noted, however, that two respondents opposed this pessimistic assessment, and commented that they perceived *increases* in expertise in all three anatomical areas.

Question 12.—Respondents were asked to rank four sources of data—study skins, skeletons, spirit specimens and genetic material—based on their view of the role these have played in our *present* understanding of avian phylogeny. Responses indicated essentially a four-way tie in this assessment, with a slight preference indicated for the contribution of study skins (Table 3). The most valuable service of this ambiguous outcome is the provision of a benchmark against which responses to the following, predictive counterpart (question 13) could be viewed.

Question 13.—With respect to the four sources of information listed above, respondents considered *genetic material* to hold the greatest promise for *future* insights into avian phylogeny; the other three options divided the remaining support approximately equally (Table 3).

Question 14.—Respondents considered *spirit specimens* to be approximately twice as important as either study skins or skeletons for an understanding of the functional anatomy of birds (Table 3).

Curatorial concerns

Four questions concerned comparatively practical aspects of the curation and use of spirit specimens. These were included to assess the potential for such concerns to deter curatorial staff members from allocating new specimens to fluid-preserved collections.

Question 15.—Several frequently cited issues attending spirit specimens—including toxicity of formalin, combustibility of ethanol, breakage of glass containers, excessive weight of collections—were accorded equal weight by respondents (Table 3). Under 'other', several respondents listed failure of seals on containers and the likelihood that ethanol would escape and permit desiccation of the specimens.

Question 16.—Of the various accidents that can occur in the preparation or study of spirit specimens, eight respondents listed lacerations with dissection or injection equipment, seven listed excessive exposure to ethanol or formalin (by inhalation and/or spillage), five reported cuts on broken glass, and four indicated other mishaps (Table 3).

Question 17.—Although the combustibility of ethanol in collections of spirit specimens has not been confirmed as a significant problem, there is a widespread perception that this risk exists. Accordingly, local fire codes in many regions impose special conditions for the storage of such specimens. This question indicated that roughly half of the respondents considered that their material was held in full compliance with fire codes, whereas the remaining respondents were approximately equally divided among the other three options (partial compliance, non-compliance or no information).

Question 18.—Access to specimens and the information these contain is of considerable scientific and ethical concern (Hoagland 1997). Given the destructive nature of most forms of study of spirit specimens (notably dissection), curators have increasingly been compelled to devise conditions or criteria for the approval of access or loans to investigators. Of the six alternatives provided, three choices (taxa involved, method of study, and experience of investigator) received slightly greater support than the other options (Table 3).

Discussion

Overview of responses

Data from several published surveys, an unpublished work by Rogers (1986), and the present survey indicate a steady but slow increase in the relative numbers of spirit specimens during the twentieth century (Table 1). Despite this trend, spirit specimens currently comprise only 2–3% of specimens held in ornithological collections surveyed. This situation appears unlikely to be reversed in the near future, as responses to the survey revealed that those responsible for allocation and preparation remain predisposed to prepare prime specimens as study skins. A substantial number of respondents prefer to preserve a critical specimen as a study skin and in various other forms (most frequently as a partial skeleton and frozen tissue).

The continuing preference for study skins stems primarily from the frequency with which the *current*, *varied* users of collections (including artists and other non-technical users) refer to these specimens. Also important to allocation decisions is a persistent, somewhat antiquated concern regarding the representation of the taxon in question as a skin specimen in the *local* collection, as opposed to basing decisions on *global* needs across all major types of specimen (e.g. as given by the *Global* *inventories*). Other concerns pertaining to collections of bird specimens in spirit—excessive weight, dangers of desiccation, and risks related to fire, toxic substances, or 'sharps' (sharp-edged or -pointed instruments)—appear to be comparatively minor impediments to the growth of spirit collections.

Contradictory attitudes and practices

Perhaps most remarkable was the contrast in motivations for preparing a specimen as a study skin, skeleton or spirit specimen, and associated estimates of the potential value of the three classes of preparation. Study skins were favoured because this form of preparation was in the highest demand among current users. Skeletons were favoured where condition of the specimen was a concern. Spirit specimens were chosen most frequently when the intention was to conserve the maximal amount of information for future study.

All three major types of avian specimen were credited with approximately equal impact on our present understanding of avian phylogeny as genetic material, but the last was accorded a significantly greater role than all three traditional preparations in furnishing insights into avian phylogenetics in the coming years. Nonetheless, spirit specimens were valued at least as much as the more abundant skeletal collections held by museums, and spirit specimens were valued significantly more than all other sources of information for studies of functional anatomy.

When viewed as a form of 'avian archive', there appears to be a conflict between the perceived value of spirit specimens and the propensity of curators to allocate new specimens for preservation in fluid. Generally, spirit specimens are acknowledged to preserve the maximal amount of anatomical information, and collections of spirit specimens are considered critical resources for phylogenetics and unsurpassed sources of information on functional anatomy. Furthermore, there was a general consensus that the anatomical expertise at highest risk in ornithology is that most dependent on the availability and study of spirit specimens. However, when faced with the opportunity to add to this valuable resource, curatorial personnel persist in a long-standing tradition of filling deficiencies in local skin collections, and turning to skeletal or (least frequently) to spirit collections only when this primary concern is appeased or the condition of the specimen renders it undesirable for this purpose.

Recommendations for the twenty-first century

Availability and quality of specimens in ornithological collections to a substantial degree dictate the course of specimen-based research to be undertaken by future investigators. Extensive new collections to serve an individual investigator are becoming increasingly difficult to justify or accomplish, and most specimen-based studies are designed in part based on the current availability of requisite material in the museums of the world. Unfortunately, this global perspective on holdings often is not shared by those who determine the fates of new specimens in ornithological collections, where parochial and seemingly insatiable preferences for skin specimens persist in a significant number of (especially smaller) museums. Spirit specimens are uniquely informative for a number of critical aspects of ornithology (e.g. phylogenetics, functional morphology and ontogeny), a need intensified by the fact that study of spirit specimens often entails various degrees of destruction (i.e. spirit specimens, like frozen tissues, are consumable).

Accordingly, I recommend that those who are empowered to allocate incoming specimens to various preparations do so as to:

(1) *minimise what is discarded* during the preparation of specimens by storing specimens material in multiple ways (see, e.g., Eames *et al.* 2002);
(2) serve *future* investigators *at least* as much as current users;
(3) preserve *maximal information*, perhaps best achieved through preservation of a spirit specimen, frozen tissue samples and digital photographs of the fresh specimen;
(4) complement g*lobal* as opposed to local deficiencies in holdings (cosmopolitan perspectives being appropriate for a future in which museums will be increasingly connected by electronic media); and
(5) *create uniquely valuable collections* not attainable by other means, e.g. ontogenetic series in spirit, and special preparations to facilitate the study of challenging organ systems or tissues.

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Appendix

Questionnaire regarding avian spirit collections

Instructions regarding ranking.—If possible, use the integer ranking recommended parenthetically in each question in your responses. In the event that you feel that two or more options merit the same rank, then assign them the same integer value; e.g. for four alternatives in which two options are considered to have equal, intermediate ranks, then the integers assigned would be 1, 2, 2, 3. If you consider any option to be completely irrelevant to a particular issue, assign it a rank of zero.

1. Please indicate the normal priority assigned to the three classes of preparation in your institution for a single, newly acquired and valuable specimen of bird (e.g. new distributional record, representative of endangered species) (1 = highest; 2 = intermediate; 3 = lowest): (a) skin; (b) skeleton; (c) spirit.
2. Do you or your staff consult the *World inventory of avian spirit specimens* (Wood *et al.* 1982) or the *Revised world inventory of avian skeletal specimens* (Wood & Schnell 1986) in allocating specimens for preparation? (a) yes, I consult both inventories; (b) yes, but I only consult the spirit inventory; (c) yes, but I only consult the skeleton inventory; (d) no, I do not consult either inventory.
3. Please rank the following rationales *to the extent that you are in agreement with them* as justifications for allocation a critical specimen to be prepared as a **study skin**. (Please rank as '1' the rationale with which you are in strongest agreement, '2' for next-most important reason listed, etc., with '8' being used for the reason you find least compelling): (a) preparation preserves the maximal amount of anatomical information; (b) preparation is easiest to prepare; (c) preparation is easiest to curate; (d) preparation is sought most frequently by ornithologists using collection; (e) preparation is most appropriate given the condition of the specimen; (f) preparation conforms to the primary form curated at the facility; (g) preparation is of greatest interest or utility to the individual making the

allocation or to his/her colleague(s); (h) preparation is a condition of acceptance imposed by collector or donor.

4. Please rank the following rationales *to the extent that you are in agreement with them* as justifications for allocation a critical specimen to be prepared as a **skeletal specimen**. Same instructions and options as in Question 3.
5. Please rank the following rationales *to the extent that you are in agreement with them* as justifications for allocation a critical specimen to be prepared as a **spirit specimen**. Same instructions and options as in Question 3.
6. Please rank the following possible explanations for the relative rarity of spirit specimens in global ornithological collections (1 = most plausible, etc.): (a) spirit specimens retain the least amount of readily usable information; (b) spirit specimens are comparatively difficult, unpleasant or expensive to prepare and curate; (c) spirit specimens are only infrequently sought by ornithologists; (d) spirit specimens are messy to examine; (e) spirit specimens require very technical training to study properly; (f) spirit specimens suffer damage if dissected, and therefore curators are comparatively restrictive regarding access; (g) study skins were strongly favoured as specimens during much of the twentieth century in most museums.
7. In your facility, what is (are) the position(s) of the individual(s) who allocate incoming specimens as to form of preparation? (If this process varies, please indicate the most frequent option as "1" and the next most frequent as "2", etc.): (a) curator in charge; (b) curators as group; (c) collection manager; (d) preparator or technician; (e) other (specify).
8. Please rank the following motivations for an increase in spirit specimens of birds in your collection during the next decade (1 = most plausible, ..., 10 = least plausible): (a) receipt of numerous specimens for which there was low interest in alternative preparations; (b) arrival of new staff member or nearby colleague with interest in study of spirit specimens; (c) increase in importance of spirit specimens in your own research programme; (d) receipt of numerous specimens that were not considered suitable for alternative preparations; (e) professional concern for preservation of entire specimens for posterity; (f) increased familiarity with procedures for preparation and care of spirit specimens; (g) mandate from higher administration; (h) provenance of specimen (i.e. wild-taken or captive); (i) completeness of data associated with specimens; (j) indications of disease in the specimens.
9. If your collection was given a fresh specimen of a previously unknown species of bird that is of sufficient rarity that it could be assumed that no more specimens would be collected in the future (i.e., your specimen is assumed to represent the unique voucher for the species), which of the following preparations would you recommend (check [tick] more than one if a combination of preparations would be used): (a) study skin; (b) full skeleton; (c) study skin and partial skeleton; (d) study skin with skull removed ("schmoo") and partial skeleton; (e) entire spirit specimen; (f) frozen tissue specimen(s); (g) internal organs in spirit.
10. Please rank the following justifications for method of preparation for a newly acquired specimen to be added to your collection (1 = most important consideration, ..., 5 = least important): (a) availability/abundance of the taxon as a skin, skeleton or spirit specimen in the museums *of the world*; (b) availability/abundance of the taxon as a skin, skeleton or spirit specimen in the museums *of your country or continent*; (c) availability/abundance of the taxon as a skin, skeleton or spirit specimen in *your collection*; (d) utility of the preparation of the taxon to your own research; (e) preparatory skills of you or your staff.
11. Please rank the following skills by decline in expertise (regardless of reason) during the last 20 years in ornithological institutions worldwide (1 = greatest decline,..., 3 = least decline): (a) illustration/technical description of external appearance of birds; (b) identification/classification of skeletal elements; (c) description/illustration/comparative study of soft tissues (e.g., musculature, internal organs).

12. Please rank the following four classes of avian specimen by your perception of their importance to our *present* understanding of *avian phylogeny* (1 = probably most important, etc.): (a) skin specimens; (b) skeletons; (c) spirit specimens; (d) genetic material extracted from museum specimens.
13. Please rank the following four classes of avian specimen by your perception of their importance to our *future* understanding of *avian phylogeny* (1 = probably most important, etc.): (a) skin specimens; (b) skeletons; (c) spirit specimens; (d) genetic material extracted from museum specimens.
14. Please rank the following three classes of avian specimen by your perception of their importance to our understanding of *functional anatomy* (1 = probably most important, etc.): (a) skin specimens; (b) skeletons; (c) spirit specimens.
15. Please indicate which (if any) of the following concerns are held by you or your staff have regarding the preparation and storage of fluid-preserved specimens: (a) toxicity of formalin; (b) combustibility of ethanol; (c) risk of breakage of glass jars; (d) weight of collection with respect to structural limitations of facility; (e) other (specify).
16. Please indicate which of the following mishaps (if any) have happened in your facility during the preparation and storage of fluid-preserved specimens: (a) staff member or visitor suffered cut from broken glass; (b) staff member or visitor suffered from exposure to ethanol or formalin; (c) staff member or visitor suffered cut during dissection or injection; (d) staff member or visitor spilled significant quantities of ethanol or formalin on him-/herself or clothing; (e) other (specify).
17. Does your collection of spirit specimens meet local fire and safety codes? (a) yes, completely; (b) yes, with following exception(s); (c) no; (d) do not know; (e) there are no applicable codes.
18. Please rank the criteria considered by you in granting use of spirit specimens by visitors (1 = most important, ..., 6 = least important): (a) taxa involved; (b) nature of dissection intended; (c) outcome of prior study by visitor in question; (d) publication record of visitor; (e) reputation/experience of visitor with techniques intended; (f) personal familiarity with visitor.
19. Please provide the total number of **skin** specimens in your collection (if not sure, please give your best estimate and enclose the figure in parentheses).
20. Please provide the total number of **skeletal** specimens in your collection (if not sure, please give your best estimate and enclose the figure in parentheses).
21. Please provide the total number of **spirit** specimens in your collection (if not sure, please give your best estimate and enclose the figure in parentheses).
22. Do you or your staff prepare **skin/partial-skeletons**? Please check [tick] the most appropriate response: (a) no; (b) yes, but rarely; (c) yes, routinely.
23. Do you or your staff prepare **skin/partial-spirits**? Please check [tick] the most appropriate response: (a) no; (b) yes, but rarely; (c) yes, routinely.
24. Please indicate the number of staff members who work in the ornithological collection in your institution at present (tally in full-time equivalents).
25. Please indicate the number of years that you have been a professional, museum-based ornithologist.
26. Please indicate the number of graduate students using museum specimens in their research with whom you have been involved professionally during your career.
27. Please list the top five areas of personal research that involve to a significant extent specimens of birds (e.g., geographic variation, functional anatomy, paleontology, illustration).

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DNA and the museum tradition

by Leslie Christidis & Janette Ann Norman

SUMMARY

DNA analysis is now a cost-effective and routine technique in systematics, taxonomy and population biology. Natural history museums need to maintain their relevance to these advances by expanding and diversifying their collection holdings. We describe different DNA-based techniques, the type of material required, and the most appropriate methods of storage. The needs of DNA-based research point the strategic direction for future collection development in museums. Traditional specimens (e.g. skins and skeletons) as sources of material for DNA-based studies are also discussed. We identify areas of concern associated with the use of DNA material for systematic and taxonomic studies, e.g. voucher specimens, museum accession numbers and other information standard in morphological studies but often lacking in DNA-based analyses. Museums must play a key role in ensuring that the necessary specimen information is included in publications. The relationships and obligations of museums and the researchers who obtain material from them are explored.

Introduction

Museum collections have traditionally been wholly specimen-based. In the case of birds these include skins, skeletons and spirit specimens. Such collections have been essential to the study of the systematics, evolution, biogeography and functional morphology of birds. Skin collections in particular have been important in documenting regional variation in avian species. While skins dominate most museum avian collections, they are not as adequate as we would like when it comes to documenting such things as geographical, age and sex variation (Zusi 1982, Winker *et al.* 1996, Schodde & Mason 1999). Skeletal and spirit specimen holdings are very small by comparison (Jenkinson & Wood 1985, Livezey 2003, Olson 2003). These traditional museum collections are, and will continue to be, important resources for evolutionary, biogeographical and systematic studies of birds. However, the development of new biological tools means that museums need to expand and adapt their scope of holdings in order to continue to be at the forefront of relevance for such studies. The most significant developments have been in molecular genetics, given the ease with which we can now obtain protein allozyme and DNA sequence data for phylogenetic and population studies (Richardson *et al.* 1986, Avise 1994).

Maintenance of material for genetic studies

The earliest widely used molecular technique was protein allozyme electrophoresis, which required freshly collected tissue samples or blood that was then stored in ultra-cold freezers (e.g. Richardson *et al.* 1986). Proteins degrade relatively rapidly when stored in standard freezers (-20°C), and denature when stored in ethanol.

Consequently, the growth of protein electorophoresis as an evolutionary tool started the development of ultra-cold tissue banks in universities and museums.

With the advent of the polymerase chain reaction (PCR) (Saiki *et al.* 1988), techniques such as direct sequencing of DNA became relatively fast and affordable. The tissue banks first established for protein allozyme studies now became just as important for DNA sequencing and other DNA based studies. DNA is much more robust than proteins and can be obtained from samples stored in ethanol (Houde & Braun 1988), buffers (Seutin *et al.* 1991, Amos & Hoelzel 1991, Arctander & Fjeldså 1994), standard freezers, as well as from traditional museum specimens such as feathers (Ellegren 1991, Leeton *et al.* 1993), skin (Thomas *et al.* 1989), scrapings from foot pads (Mundy *et al.* 1997) and bone (Cooper *et al.* 1992).

The ability to use a variety of specimen materials for DNA study has meant that natural history museums now need to address the following issues:

- What sorts of research will in the future require DNA samples?
- What are the most common and widely applicable molecular techniques relevant to museum holdings?
- What sorts of samples are required for these techniques and how do these relate to current museum practices regarding specimen collections?
- What are the future directions that museums should go down to make their collections useful for systematic and evolutionary studies using molecular approaches?
- How can museums use these advances to enhance the information content of their existing collections?

What sorts of research are being conducted using DNA samples?

One of the appeals of using DNA sequence data to address systematic questions is that they can be used at a range of taxonomic levels, from the status of particular taxa (e.g. Norman *et al.* 1998, Alström & Olsson 1999, Irwin *et al.* 2001, Norman *et al.* 2002) through to the systematic relationships between species and genera (e.g. Espinosa de los Monteros 1998, Omland *et al.* 1999, Johnson *et al.* 2001, Whittingham *et al.* 2002), families (e.g. Moore & DeFilippis 1997, Johnson *et al.* 2000, Barker *et al.* 2002, Ericson *et al.* 2002) and orders (e.g. Mindell *et al.* 1997, Paton *et al.* 2002). These DNA-based approaches should not be viewed as a replacement for morphological studies but rather as a complement. Nevertheless, in many cases where the systematics were based on characters associated with feeding and locomotion, molecular approaches have provided strong evidence that numerous examples of convergence had been overlooked (e.g. van Tuinen *et al.* 2001). As the number of nuclear and mitochondrial DNA sequences used to reconstruct phylogenies increases, these will become robust frameworks from which morphological variation can be interpreted. Molecular phylogenies combined with comparative approaches (Brooks & McLennan 1991, Harvey & Pagel 1991) have been used to trace the evolution of features such as breeding behaviour (Poiani & Pagel 1997), sexual dimorphism (Burns

1998), plumage patterns (Espinosa de los Monteros 1998, Omland & Lanyon 2000) and ecology (Richman & Price 1992, Richman 1996, Cicero & Johnson 1998).

Another broad area of DNA-based research focuses on documenting genetic variation within species. This includes looking at the taxonomic status of isolated populations (e.g. Norman *et al.* 1998, Irwin *et al.* 2001), the partitioning of genetic variation across the distributional range of species (e.g. Edwards 1993, Rising & Avise 1993, Baker & Marshall 1997, Milá *et al.* 2000, Liebers *et al.* 2001) and its relationship to conservation (Avise & Nelson 1989, Norman & Christidis 1997, Robinson & Matthee 1999, Pestano *et al.* 2000, Zink *et al.* 2000). Repetitive DNA markers such as multilocus fingerprints and microsatellites can also be used in behavioural studies (Burke 1989, Queller *et al.* 1993, Painter *et al.* 2000, Semple *et al.* 2001, Conrad *et al.* 2001).

Comparative genomics is a new and rapidly developing field of research which may increasingly rely on museum collections as a source of material. Comparative genomics involves the isolation and characterisation of specific genes from different organisms in an effort to understand their structure, function, mechanisms of regulation and evolution. Although domesticated species have been the major focus of research to date, there is increasing interest in studying the genomes of native species (Couzin 2002).

What are the most common and widely applicable molecular techniques?

The molecular techniques used commonly today in evolutionary and systematic studies can be divided into two groups: those that are PCR-based and those that are not. These two broad groups relate directly to the types of tissue or specimen material that can be used, amount required and preferred method of preservation.

The most widely used non-PCR techniques have been protein allozyme electrophoresis (e.g. Richardson *et al.* 1986), multi-locus DNA fingerprinting (e.g. Jeffreys *et al.* 1985), and DNA-DNA hybridisation (e.g. Sibley & Ahlquist 1990, Sheldon *et al.* 1995). Here a limited number of tissue sources can be used. For example, protein allozyme analysis requires frozen tissues while good-quality DNA is required for DNA fingerprinting.

The most widely used PCR-based techniques are direct sequencing of mitochondrial (e.g. Mindell *et al.* 1997, Paton *et al.* 2002) and nuclear (e.g. Prychitko & Moore 1997, Groth & Barrowclough 1999, Barker *et al.* 2002, Ericson *et al.* 2002) DNA, and microsatellite analysis (e.g. Queller *et al.* 1993, Painter *et al.* 2000, Semple *et al.* 2001, Conrad *et al.* 2001). PCR-based techniques only require small amounts of intact or even degraded DNA (Pääbo 1989). Consequently, there is great flexibility on the types of material that can be used with such techniques.

In the new field of comparative genomics the primary demand will be for high-quality frozen tissues from which intact DNA and RNA molecules can be isolated. RNA is more susceptible to damage than DNA and must be stored under ultra-cold conditions. RNA is used to isolate specific gene sequences using reverse-transcriptase PCR and to establish gene libraries containing all expressed DNA sequences (i.e.

those portions of the DNA that encode genes). These are termed Expression Sequence Tagged or EST libraries.

DNA from museum specimens: advantages

As discussed above, DNA that is suitable for analysis can be obtained from bone, feather bases, scrapings of foot pads and pieces of skin from museum specimens. The success of this is related to the age of the specimen. The older the specimen the more degraded is the DNA (Pääbo 1989). However, there is also variation between similarly aged specimens. Moreover, from some individuals it almost impossible to extract DNA. This might be a reflection of the types of preservatives used (Cooper 1993). DNA can sometimes be obtained from formalin preserved material (Shibata 1994), but formalin fixation causes significant sequence alterations (Williams *et al.* 1999) which can be misinterpreted as genetic variation. Nevertheless, protocols for obtaining good-quality DNA from formalin-fixed specimens are continually being developed (e.g. Coombs *et al.* 1999, Shi *et al.* 2002).

DNA studies based on frozen tissue samples can suffer from a lack of coverage of species and geographical areas in current collections. The availability of appropriate samples has been identified as a severe bottleneck for molecular evolutionary studies (Arctander & Fjeldså 1994, Winker *et al.* 1996). Omland *et al.* (1999) pointed out the importance of comprehensive species coverage, including subspecies, in constructing well-resolved molecular phylogenies. The ability to use existing museum skins (e.g. Dumbacher & Fleischer 2001) and skeletons for DNA-based studies (e.g. Paxinos *et al.* 2002, Shapiro *et al.* 2002) therefore provides an enormous resource in terms of species coverage, localities, the number of specimens and temporal sampling. Using museum skins is often the only way of working on rare, endangered (Norman & Christidis 1997) or extinct (Christidis *et al.* 1996) species. Instead of leaving out such critical species, museum skins allow their inclusion in molecular phylogenetic studies.

Museum collections also provide an historical perspective, as the specimen series from some regions can span decades. Such temporal series can be used to investigate the onset and impact of recent hybridisation events, range expansions and contractions, and allow us to investigate temporal variation in levels of genetic diversity (e.g. Thomas *et al.* 1990, Lambert *et al.* 2002, Paxinos *et al.* 2002).

DNA from museum specimens: disadvantages

Despite the advantages of coverage provided by existing skin and skeletal collections, there are several limitations and problems associated with only using such material for DNA studies.

The most obvious concern is that such sampling requires the removal of feathers, skin or other material from fragile and valuable specimens (Graves & Braun 1992). It is a form of destructive specimen sampling. While this may not be a problem for common species where numerous specimens will exist in collections, it will be of concern when rare, extinct or unique material is sampled. Furthermore, it is with these latter taxa that tissue material will most probably be unavailable and taxonomic or evolutionary questions will exist. Consequently, it is on such valuable specimens that most pressure will be placed (Graves & Braun 1992).

Another problem with using museum specimens relates to the quality of the DNA obtained. DNA from museum skins and skeletons is degraded (Pääbo *et al.* 1989, Handt *et al.* 1994). Therefore, the DNA fragments that can be amplified using PCR will often be small, around 200 base pairs or fewer (Handt *et al.* 1994). From fresh material it is possible routinely to amplify fragments of 1,000 to 2,000 base pairs. Another limitation of using museum skins and skeletons is that only relatively small amounts of DNA can be obtained. Both these factors will increase the time and costs of a DNA study. With the relatively small amounts of DNA that will be obtained there will be a limit as to the number of PCR reactions that can be performed from any one extraction.

There are also age-related artefacts where post-mortem changes in the DNA can be misinterpreted as genetic variation. This is most likely to be a problem when analysing microsatellites (Gagneux *et al.* 1997).

A bigger concern with using museum skins and skeletons for DNA study is ensuring that the correct genome is being sampled. There are two problems here. The first is contamination. Because only small amounts of degraded DNA will be obtained from museum specimens there is a greater risk that extraneous DNA from other sources will be preferentially amplified (Handt *et al.* 1994). Controls and stringent laboratory techniques are critical to avoiding contamination in such studies.

The second problem, harder to control, is validation of the sequences. Most phylogenetic studies concentrate on the rapidly evolving mitochondrial genome (Avise 1994). However, it is now well established that multiple copies of mitochondrial genes can exist in the nuclear genome (Sorenson & Quinn 1998, Nielsen & Arctander 2001). Using PCR there is always the possibility that a nuclear copy of a mitochondrial gene will be amplified instead. Comparing a mixture of mitochondrial and nuclear sequences in a phylogenetic analysis will lead to highly misleading results (e.g. Arctander 1995).

With frozen tissue samples it is possible to purify mitochondrial DNA (Tamura & Aotsuka 1988), thereby decreasing the chance of amplifying nuclear copies of mitochondrial genes. Unfortunately, this is not possible with museum skins given the degraded nature of the DNA. One approach is to obtain sequences from purified mitochondrial DNA and from total DNA extracted from museum skins for the same species, and then compare the two to confirm that similar sequences are being obtained from both DNA sources (e.g. Norman *et al.* 1998).

Museums and tissue collections

It is clear from the previous discussion that traditional skin and skeletal collections alone are not sufficient for DNA-based evolutionary studies. These collections should be seen as a supplement to continued tissue bank development. Even so, museums are generally the most appropriate institutions for establishing specialist tissue collections. They have the expertise and facilities for long-term taxonomic research, collection and data management, and are often the official regional faunal repositories.

In establishing tissue collections, issues that need to be considered include:

- types of tissues to be stored
- whether to link all tissues to vouchers
- methods of preservation
- storage facilities

Obtaining tissue samples

When collecting specimens, skeletal muscle, heart and liver provide excellent sources of DNA. However, liver should only be collected from freshly dead birds as the DNA in liver degrades more rapidly. When sampling DNA from specimens that have been dead for some weeks, feathers or foot pads provide the best source of relatively undegraded DNA.

For non-destructive sampling, blood and feathers are both suitable (Arctander & Fjeldså 1994). The removal of body feathers is preferred as it is much simpler, and adequate DNA samples can be obtained from one or two body feathers of larger species. While pin feathers provide the best source of DNA these are not always easy to obtain. To minimise harm to the bird it may also be better to obtain several body feathers than one or two primaries.

Taking blood samples is more complicated as it causes stress to the bird and requires certain skills on the part of the field researcher. With blood there is also a greater chance of amplifying nuclear copies of mitochondrial genes because avian red cells are nucleated and have low concentrations of mitochondria (Quinn 1992, Sorenson & Quinn 1998).

The need for linkage to vouchers

Concerns have been raised on the use of tissues or feathers that are not linked to voucher specimens in DNA studies (Winker *et al.* 1996). These are valid for phylogenetic studies where each species may only be represented by one individual. Misidentification of a specimen can have serious effects here. Consequently, vouchers are necessary for species that are hard to identify from other similar-looking species, where hybridisation is an issue, and where cryptic species may be suspected to exist.

For population studies of easily identified birds the need for vouchers may not be as great. Even for difficult species misidentification may be a minor problem if material is obtained from experienced researchers dealing with a local population study. Researchers studying the ecology and behaviour of a particular species can provide non-destructive samples of feathers and blood without the risk of misidentification. In fact, this is one fruitful way of obtaining material from highly threatened species. Wildlife managers involved in the translocation of individuals can collect non-destructive samples, which can then be used for DNA study. It is relatively easy to carry appropriate sample tubes routinely, so that material suitable for DNA study can be obtained whenever a bird is being handled.

Museums need to develop strategies on how to deal with such non-voucher-based samples. Rejecting all tissue/feather material without vouchers may appear to be a sound scientific policy but it is also highly restrictive, particularly for population studies. Museum curators and collection managers are in the best position to ascertain the quality of material, in terms of identification and use, before incorporating it into tissue banks. Such material should be flagged as lacking a voucher as this may impact on the type of study for which it is later used.

Methods of tissue preservation

The most effective long-term method of storing tissue for molecular analyses is ultra-cold freezing. This requires a significant commitment in facilities for a museum. Ultra-cold freezers are expensive and require some form of back-up system. Field collecting for ultra-cold storage is also difficult. Obtaining and transporting liquid nitrogen and dry ice is not practical in many field situations. Servicing loans is also a complicated process in terms of the practicalities of transporting frozen material and quarantine issues. Standard freezers are not a good option for long-term tissue storage, as some enzyme activity will continue at that temperature which will lead to degradation of the DNA.

There are alternative storage methods for tissues. Tissue samples can be stored in ethanol and used for DNA analyses (e.g. Houde & Braun 1988). While ethanol may not be an ideal system for long-term storage compared to ultra-cold freezers, it does have many practical advantages. It is more cost-effective for smaller museums and those in less developed countries. No additional storage facilities are required, as most museums already have ethanol-preserved specimens. Ethanol storage is also highly convenient for field collecting, although this may not be the case in countries where alcohol is prohibited on religious grounds.

The DNA from ethanol-preserved specimens will degrade to some extent due to endonuclease activity (Houde & Braun 1988). Although ethanol stops endonuclease activity, it is important that the ethanol permeate the tissue sample completely and rapidly. Tissue samples should be sectioned into small portions so that this can occur. It is also important that the samples be stored in such a way that evaporation of the ethanol is minimised, and that only highly pure ethanol is used.

Tissues can also be stored in a variety of buffer solutions at room temperature (Amos & Hoelzel 1991, Seutin *et al.* 1991, Arctander & Fjeldså 1994). For long-term storage refrigeration is probably better. The drawback with buffers is that access to distilled water, fine balances and autoclaves is required to prepare the buffer solutions. Although Arctander & Fjeldså (1994) were able to extract DNA with no detectable degradation from material stored in buffers for five years, our experience has been that buffer-stored material provides variable results.

One limitation of both ethanol- and buffer-stored material is that it may not always be possible to obtain purified mitochondrial DNA. This can be a problem where nuclear copies of mitochondrial genes are an issue.

Storage facilities

As not all museums will have the capabilities to establish ultra-cold tissue banks, alternative systems need to be considered. The pooling of resources across museums and establishing centralised ultra-cold tissue collections is a possible solution. An advantage to users is that it is easier to source material from a single centralised collection. For the participating museums issues relating to individual roles, responsibilities, databasing, acknowledgment and benefits would need to be addressed.

Ethanol tissue storage should be possible for all museums, and is suitable for most samples. However, some material from highly rare species should still be kept in an ultra-cold facility. At least some representation of each species should also be stored in ultra-cold conditions. A combination of centralised ultra-cold and individual ethanol tissue banks is an option worth exploring.

Responsibilities of museums and users

Samples for DNA work are a form of destructive sampling. Therefore it is important that the objectives and scope of the work are defined before loans are approved (Arctander & Fjeldså 1994). With requests for feathers, skin or bone from museum specimens, material should not be provided until a strong case is presented that the requesting researcher has the technical skills, experimental design and facilities to extract and sequence DNA from such material.

For all DNA studies, the material should only be used for the agreed specified project (Arctander & Fjeldså 1994). All excess material and DNA must be sent back and material or DNA should not be given to a third party without prior consent.

It is important that researchers include accession numbers of the tissues and vouchers when they publish sequences. This is needed so that the same bird is not sequenced by different laboratories and then treated as an additional data point. Information on locality and subspecies should be included as well (Hackett *et al.* 1995). The collection and collectors (if appropriate) should be acknowledged in publications. Such information is taken for granted when morphological analyses are published but it has not been common practice in molecular studies. Museums can play a role in introducing such rigour by making it a condition of using either museum specimens or tissues for DNA work.

When using material that is not linked to a voucher, it is still important that there is a tissue accession number and that it be cited in the publication. Again this is to ensure that specimens can be tracked across studies. It is also useful to have researchers provide the sequence information to the museum so that this information can be then linked directly to the specimen's database record.

Researchers not linked to museums but who have collected material for their own studies should be encouraged to lodge any material left after completion of their study with an appropriate museum. Often this excess material lies forgotten in university freezers or drawers and is eventually discarded. This is a loss of potentially very useful material that should be accessible to the wider scientific community by being incorporated into a museum collection.

Museums which have made an effort to build up DNA collections are often reluctant to provide samples to research groups that consistently make no effort to supplement these collections or to contribute their own resources towards securing material. Some museums have responded to this issue by imposing charges for tissue loans, but this is contrary to the spirit of cooperation that has been the tradition of museum specimen-based research. The imposition of charges ultimately discourages researchers from lodging material in museums. More positive approaches would be to (1) build alliances between institutions and researchers that undertake molecular systematic and evolutionary research *and* are willing to provide material to each other when needed; and (2) encourage non-museum researchers who make loan requests for DNA material to collect (where possible) and lodge material in appropriate museum collections. Museums have a responsibility to ensure appropriate use of their collections. As with any loan request we have the right of refusal if it is deemed to make inappropriate use or places excessive demands on the collection.

Future directions for museum collections and DNA research

In developing tissue collections museums need to identify those areas that are poorly covered in current holdings in terms of species and geographical distributions. It is important that the development of tissue banks be integrated with that of skin and skeletal collections. All specimens collected should have material lodged as either frozen or ethanol-preserved tissue.

Another factor that needs to be considered when developing tissue banks is the type of study the collections are being used for. The most common use for DNA material from museums is for studies addressing systematic and phylogenetic questions. Often the requests for material involve single representatives from species and subspecies. There is less call for material to be used in population studies, even though avian molecular ecology has been a rapidly growing area in recent years. These latter studies require larger numbers of individuals per species, but few species are currently represented by large numbers of frozen tissue samples (Arctander & Fjeldså 1994).

Museums can take active measures to become more relevant for population and ecological studies. Museums are often the regional repositories for fauna found dead. Tissue or feather samples should be routinely obtained from all specimens lodged with a museum. In this way large collections of the commoner species will accumulate.

With most museums that were contacted, the greatest users of the tissue banks were internal staff from the museums themselves. The development of tissue banks and in-house expertise and facilities for molecular-based research were correlated. This is understandable given that collection development is often driven by the research interests of curators. This is a strong reason why the collecting of material suitable for DNA study should be integrated with general collection growth.

Enhancing existing museum collections

Museums should also be aware that DNA technology has the potential to add information to existing collections. Several PCR-based DNA markers have been developed that are sex-linked across a range of taxa (Griffiths *et al.* 1998). Consequently, it might be possible to sex museum specimens using DNA. This would be of benefit with unique or rare unsexed specimens, immatures or those with doubtful sex assignments. Clearly the costs involved would make this avenue only appropriate where sex information is critical. DNA sequencing has also been used to determine the taxonomic status of species based on a single museum specimen (Joseph *et al.* 1999). DNA information can determine whether the unique specimens represent colour variants, preservational artefacts or species hybrids. In all the above examples DNA studies can be used to enhance the information content of collections.

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DNA and protein sequence databanks: some caveats

by K. M. Rajkowski

It is known that conventional museums contain specimens that are mislabelled, incomplete or so damaged as to be unusable, and that some specimens will have been mislaid or lost. It is less obvious that 'silicon museums', such as Genbank and EMBL, which comprise collections of DNA and protein sequence data, also suffer from similar problems. With these problems comes the corresponding risk of compromising increasingly popular molecular phylogenetic studies. Here, types of problem and reasons for suspicion of certain sequences, as well as examples of the inutility of others, are outlined and methods for detecting some errors proposed.

Examples were found in the 2,470 mitochondrial cytochrome b sequence entries obtained by searching the EMBL v.60.0/EMBLNEW v.61.0 databank, updated to 3 November 1999 (5,087,527 sequences), using the keyword 'cytochrome b'. Each entry consists of a *label*, identifying and describing the origins of the sequence, and a *specimen*, the DNA and translated protein sequences.

Problem entries included: (1) specimens too fragmentary for use—as few as 13 nucleotide base pairs. Only a minority of specimens are of the minimum number of base pairs (approx. 900) needed for protein molecular phylogenies when other genes for the correponding species have not been sequenced (as is mostly the case); (2) specimens where the proportion of undetermined nucleotides was so large that the sequence was unusable; (3) specimens where the DNA sequence had been translated into the protein sequence using the wrong genetic code (nuclear instead of mitochondrial); and (4) specimens not identified to species level (i.e. unlabelled). Mislaid specimens, not found in the search but present in the databank, included 14 *Phylloscopus* (leaf-warbler) sequences (because of a typing error in their labels ['cytochorome b']), and 44 sequences for Corvidae (crows), Sylviidae (warblers) and Timaliidae (babblers) only found using other keywords. Lost specimens included seven *Phylloscopus* sequences published in 1992 but still absent from the databanks. Furthermore, many entries were confirmatory replicates that could be combined into a single sequence entry with the corresponding annotations on the label.

While many such problem entries should be detectable with appropriate computer programmes rather than 'manually' searching through (in the case of cytochrome b sequences) some 3,000 pages of text, the problem of sequencing errors remains. It is estimated that, on average, 0.1% of the nucleotides in databanks are mis-sequenced and, for methodological reasons, errors will be more frequent in some sequences than others. Some probable nucleotide sequencing errors are detectable provided they give rise to improbable amino acid substitutions in the translated protein, and for this reason it is recommended that the protein sequence be compared with those of related species prior to using the nucleotide sequence in a phylogenetic study or, preferably, before submitting it to a databank.

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History *vs* mystery: the reliability of museum specimen data

by Pamela C. Rasmussen & Robert P. Prŷs-Jones

SUMMARY

Museum specimens are consistently the most reliable source of many types of information for bird species. While the vast majority of bird specimens provide accurate data that form the baseline of knowledge of bird distributions, a small percentage of specimens carry various types of misinformation, and to maximise the utility of specimen data and avoid perpetuation of errors, users need to be aware of and able to evaluate these problems. This paper discusses and provides examples of many types of misinformation on specimen labels, which include over-generalised or untraceable locality information, careless labelling, consequences of the profit motive among dealers, inadequate training and supervision of collectors, inappropriate curatorial techniques, problems in deciphering and interpreting label data, and fraud. Inadvertent problems such as imprecision and untraceability of localities and other data, as well as subsequent improper curatorial treatment, are common among older specimens, while known cases in which specimen data have been intentionally compromised tend to be rare and small-scale. The most notable exception is the Meinertzhagen Collection, which contains numerous stolen specimens bearing fraudulent data, as well as important specimens with genuine data.

Introduction

The collectors' old adage 'What's hit is history, what's missed is mystery' reflects a deep-seated and well-founded belief in the importance of the tangible evidence represented by the museum specimen. Certainly when compared with the multitude of chronic problems associated with sight records (jokingly summed up as: 'I wouldn't have seen it if I hadn't believed it'), specimen documentation allows more critical and objective study, not only now but also in the future, when new technology and methodology may be available. It is, however, self-evident that the accumulation, maintenance and interpretation of ornithological specimens will continue to be subject to errors of various types and, to a lesser extent, to pathological behaviours; indeed, the literature is replete with suspected or confirmed cases of problematic specimen data. Even so, specimens are being increasingly used in many applications by persons distant from, and unfamiliar with, the historical framework that makes many specimen-related problems transparent, so these data are often uncritically assimilated in the literature. The subject of specimen-based misinformation in ornithology seems not to have been reviewed, a deficit this paper attempts to redress in support of a more confident and accurate utilisation of museum material by future workers.

We review specimen-related misinformation of various categories, beginning with the often pervasive but typically minor types of 'noise' due to carelessness and casual error, and progress through to rarer but more pernicious (on a case-by-case basis) instances of outright fraud involving specimens. However, the ubiquity of the minor types of specimen misinformation probably makes their cumulative negative effect on ornithology greater than for fraud. Our focus is on the numerous problems that can arise from the specimens and their associated data, but we stress that the very existence of the specimen enables independent, scientific evaluation of its validity, and that some such methods deserve more widespread application. By its nature, the matter under discussion typically involves individual collectors, but our concern is exposition of the problems, over and above personal considerations.

Outside the scope of our review are: specimen-based (and extremely important) sources of error such as misidentifications, hybrids and aberrant or composite individuals; lost or destroyed specimen documentation; and mistakes and misinterpretations of specimen data in specimen catalogues, the published record (as distinguished from errors in baseline data) and, increasingly, in databases. While we recognise that specimen data problems stemming from the earlier years of ornithology are even more prevalent and often less readily solved than more recent ones, our discussion primarily focuses on the latter half of the nineteenth century and later. This review provides a sample of the various types of specimen misinformation. Many additional cases have been published; others are undoubtedly known to living researchers who have not set them in writing; and others surely remain undetected or are long-forgotten. There is an extended history of critical appraisal of specimen records, typically on a regional basis, and comment will be found on the reliability of many major collections, especially the early ones, in scattered sources. Because resolutions to certain problems may seem obvious to a few but not to most, a compilation of such problems to improve the reliability and utility of ornithological collections worldwide would be a valuable long-term goal to serve current and future researchers when evaluating the probability of error or fraud in specimen data of a given collection or type.

Collectors and error

Data-poor labels

Many older museum specimens have little or no associated data. In part this is due to ambiguity or uncertainty over old national borders, but also because early scientists and collectors were unaware of the importance of precise label data, so that it was exceptional for labels to be written in the field. As a result, many early species descriptions were based on specimens of unknown, questionable or mistaken provenance. The demand for new zoological material was overwhelming, and in the early descriptive years it seemed of little consequence whether a new species came from Brazil or Peru. Since many exotic natural history specimens resulted from round-the-world expeditions, it was not uncommon for specimens to be attributed after a voyage to localities in the wrong hemispheres, witness the following Neotropical species with Old World type localities or vice versa: Collared Puffbird *Bucco capensis,* in which the specific name supposes an origin in South Africa rather than the Guianas; *Metriopelia inornata,* a synonym of the Spotted Dove *Streptopelia chinensis*, erroneously described as from Brazil instead of Java (Warren 1966); and

Buff-throated Purpletuft *Pardalotus pipra* Lesson (now *Iodopleura pipra*), who described it as 'à Trinquemalé sur la côte de Ceylan', proposed as an error for Rio de Janeiro by Hellmayr (1915). Several specimens of Hawaiian birds were labelled as from Chile, on the same shipping route to Europe, one misleading Sclater (1862) into listing an 'Elepaio *Chasiempis sandwichensis* as an undetermined tyrannid (Olson 1989); also, a specimen that almost certainly represents the type of the vanished Oahu Thrush *Myadestes lanaiensis woahensis* was registered as 'Sandw Isl. or Chili' (Olson 1996). This could happen by purchase of specimens at ports, by failure to label specimens en route, or by lack of communication between voyager and dealer or naturalist working up the results. The necessarily routine restriction and/or correction of early type localities was sometimes based on questionable or misinterpreted evidence, adding yet another level of uncertainty or error (Dickerman 1981).

Generalised locality data on older specimens risks misleading modern workers because of changes in the geographical applications of names: specimens simply labelled 'Bengal' cannot now be certainly attributed to country (either India or Bangladesh), much less to a more specific locality (Husain & Sarker 1972); 'India' on old labels could mean a much broader region than now, including areas far to the east; and 'Punjab' specimens without more specific localities could be from either present-day India or Pakistan. Numerous species were attributed to the avifauna of Bhutan owing to a misinterpretation of 'Bhootan Duars', which now lie entirely within India. Many of T. C. Jerdon's historic Indian bird specimens were labelled as from 'Madras', which then included a large portion of southern India, not just the city recently renamed Chennai.

Incomplete or generalised label data can also often be misleading on smaller scales. A taxon described from southern Sulawesi, now Rufous Fantail *Rhipidura rufifrons celebensis* Büttikofer 1893, was shown by Hartert (1896) to have been collected from smaller adjacent Tanahjampea. Although Curl-crested Manucode *Manucodia comrii* Sclater 1876 was described from the Huon Gulf, the type actually came from Fergusson Island (Frith & Beehler 1998). Specimens reportedly collected in Leyte, Philippines, were actually from the small island of Buad (Parkes 1965). Often, rather general place names were used for all specimens originating from a given segment of an expedition: Ancón was the locality recorded on the labels of 43 Peruvian Diving-petrels *Pelecanoides garnotii,* although it seems more likely that they were from the offshore Islas Pescadores (Collar *et al.* 1992). Some Ethiopian specimens of White-winged Flufftail *Sarothrura ayresi* were labelled 'Entotto', which is a ridge of wooded hills, but it overlooks the far more plausible, marshy Sululta (Ash 1978).

Of course, many localities at which birds have been collected are known by names shared with other localities. Some common ones such as 'Río Grande' are especially troublesome: in Bolivia, avian specimens bearing this name come from at least two different localities (Remsen *et al.* 1986). An attempt to trace 'Santa María, Oriente' on Cuba for Cuban Parakeet *Aratinga euops* was defeated by the sheer number of options in the available gazetteers (Collar *et al.* 1992:300); and attempts to trace 'Fategarh' (or, e.g., 'Futtegurh') and 'Rampur' in various parts of India were likewise compromised by the glut of such names in their various permutations (Collar 2001:13). Within Afghanistan, specimens have been collected at two Faizabads, on opposite sides of the country (PCR unpubl.). An 'Allahabad' specimen of Collared Pratincole *Glareola pratincola*, long thought (and recently mapped as) a vagrant to Uttar Pradesh, north-central India, is clearly really from one of several Allahabads in Pakistan, a locality specified by earlier workers and well within the species's known breeding range (Rasmussen & Anderton in press). Similar problems with African collecting localities are discussed by Dowsett (1972b), Morgan *et al.* (1978), Snow & Louette (1981), and Irwin (1991).

Careless labelling

It is typically difficult and frequently impossible to prove that any given specimen bears unreliable data, and efforts to do so often involve a degree of circular reasoning. Cautionary comments on certain collectors are commonplace, e.g. on Goodfellow and Hamilton (Zimmer 1947), Swainson (Parker & Benson 1971), Loria (Somadikarta 1975), A. Garrett (Holyoak & Thibault 1978), R. H. Lefevre (Meyer de Schauensee in Greenwood 1980), Doggett (Jackson in Cunningham-van Someren 1981) and A. Ruiz (Blair in McGowan & Massa 1990), but objective evaluation is needed in each case.

Charles Hose is best known for his pioneering Bornean collections, and had several birds named after him. However, after a short trip to northern Sulawesi in 1895, he reported four species new to that island (Hose 1903), including one new to science (*Dicaeum hosii* Sharpe 1897). The material of *D. hosii* was later shown (Stresemann 1940) to comprise two mislabelled Bornean flowerpeckers and another of a known Sulawesi species. Another species (Pied Fantail *Rhipidura javanica nigritorquis*) reported from northern Sulawesi by Hose (1903) is otherwise only known from the Philippines, and the remaining two novelties are also questionable (White 1974). These apparent errors were formerly attributed to the once-common practice of attaching printed labels to specimens *a posteriori* (White 1974), but the considerable problems with Hose (1903) suggest more catastrophic lapses on his part (see Collar 2001:792).

Several Southern Ocean procellariiform species have long been on the North American list (main or hypothetical: AOU 1983) on the basis of specimens that J. K. Townsend sent to Audubon, saying they had been procured near the mouth of the Columbia River, between Oregon and Washington (Stone 1930). Townsend, who also sent Audubon a Chilean finch *Brachyspiza* which the latter innocently named *Fringilla mortoni* (Stone 1930), is assumed to have been careless in labelling.

A number of specimens from Paraguay collected by Schulze and Haack in 1939 have caused considerable confusion: the locality (235 km W of the Riacho Negro) has proved difficult to pinpoint, their field numbers are out of sequence, dates spent at what seem to be two different sites overlap broadly, the collection contains a mixture of Chaco and Oriente species, and the labels are typewritten, indicating the strong probability of their having been prepared subsequent to the expedition (Short 1972, Hayes 1995).

Hugh Cuming (a well-known malacologist and plant collector, but the namesake of Tabon Scrubfowl *Megapodius cumingi* and Scale-feathered Malkoha *Phaenicophaeus cumingi*) was disparaged as the authority for several species from Sri Lanka by Layard (1880), who wrote 'I should be very loth to accept a "habitat" on the ground that Cuming had stated it'. Cuming's collection included the only record for Sri Lanka of Broad-tailed Grassbird *Schoenicola platyura* (otherwise a narrow Western Ghats endemic), a record which has received cautious acceptance to this day (see Collar 2001:2199). The *Schoenicola* specimen is said to have come in with others collected in Sri Lanka by T. Thwaites (Sharpe 1906), and Natural History Museum (NHM) records do not readily elucidate its acceptability. However, Cuming has also been blamed for mixing up T. Bridges's specimens from Bolivia, Chile and Argentina (Sclater & Salvin 1879), and his Philippine localities have been considered unreliable (Parkes 1961, Parkes 1988, Dickinson *et al.* 1991). Regarding Cuming's vast shell collection, it is agreed that, owing to his own carelessness and that of those who cared for his collection, many specimens are wrongly labelled or have lost their data (Dance 1966). Given such independent support for Layard's concerns about accepting locality records from specimens dealt or collected by Cuming, lone Cuming specimens, such as the *Schoenicola*, cannot be accepted as vouchers.

The failure of some collectors to label their specimens properly meant that mistakes in the hands of their agents were inevitable. Richard Crossley's pioneering Madagascar collections all passed first through a dealer's hands, and mistakes evidently occurred when the usual letter recounting Crossley's itinerary failed to accompany a shipment (Sharpe 1875, Rasmussen *et al.* 2000). M. Humblot dispersed his Comoran scops owl specimens through various agencies, and thus they bear different 'original' labels depending on the dealer or institution that handled them, suggesting subsequent labelling. This probably explains a Humblot specimen labelled 'Grand Comoro' but identical with Anjouan Scops Owl *Otus capnodes* of Anjouan and quite unlike Comoro Scops Owl *O. pauliani* of Grand Comoro (Rasmussen *et al.* 2000).

Many early collectors did not have ready-made paper labels, and often used cut-up scraps, relied on memory, or sent birds back in batches using a general locality name. Subsequent assumptions are unreliable. Charles Darwin failed to label his now-famous Galapagos finches until 'after leaving the Galapagos Archipelago in late October 1835' (Sulloway 1982a:27), resulting in considerable confusion and even unwarranted doubts as to the provenance of some of Captain Fitzroy's own carefully labelled specimens. Sharpe (1879) considered the Sulu Islands the source of a single Reddish Scops Owl *Otus rufescens* that had come in unlabelled (Guillemard 1885) along with specimens both from the Sulus and Borneo; he did not venture to name it, but Hachisuka (1934) did so, apparently assuming the correctness of the locality Sharpe had ascribed it to. The fact that the bird matches darker examples in the now-larger series from Borneo means that *Otus rufescens* cannot be maintained on the Philippines list (Dickinson *et al.* 1991).

The large collections of specimens from the Yucatán Peninsula and Cozumel amassed by George Gaumer were received enthusiastically in museums, and formed the basis of numerous descriptions of taxa and several papers. Three species of *Chaetura* alone were described by G. N. Lawrence from Gaumer's material, although for one Gaumer apparently sent Lawrence '20 tails and one entire bird' (Greenway 1978). For many years, very little else was known of birds of the region, and only later, when other collections began to come in, especially from the islands off Yucatán, did something seem amiss with Gaumer's specimens. So many of his records stood alone or flew in the face of other data that Paynter (1955) became sceptical of them. Nevertheless, Thompson (1962) published a number of Gaumer specimens as new regional records, prompting Parkes (1970) to set out the apparent problems with the material, including Gaumer's habit of sending boxes of unlabelled specimens to museums, where 'Yucatán' labels would be attached. Many records of mainland species for small islands off Yucatán and for Cozumel are still only based on Gaumer specimens, including groups typically lacking on islands such as woodcreepers and antbirds. For this reason a special category based only on Gaumer specimens was created in a table of Mexican island bird distributions (Howell & Webb 1995). Occasionally, however, species long known from Cozumel only by Gaumer skins have since been found there, e.g. Yucatan Flycatcher *Myiarchus yucatanensis* (Lanyon 1965, Parkes & Phillips 1967), illustrating the dangers of becoming over-sceptical (see also Smith 2001).

Even in recent times the problem of *post hoc* labelling has adversely affected what ought to have been valuable material. A very large collection amassed by Mario del Toro Avilés in Mexico is flawed owing to his labelling specimens long after their collection, sometimes perhaps not until they had been requested by a museum; he even admitted that a series he had labelled as from Oaxaca was actually from Puebla (Binford 1989). Some unique records from one side or other of the Isthmus of Tehuantepec, and new taxa described (e.g. Saw-whet Owl *Aegolius acadicus brodkorbi*) on the basis of the del Toro Avilés collection, therefore require confirmation (Binford 1989, Peterson & Nieto-Montes 1996).

The reliability of local collectors

Many naturalists employed locals to do their collecting, often not even accompanying them into the field. Frequently these employees excelled at the work, and obviously achieved a great deal. Inevitably, however, such staff could not be expected always to produce specimens with reliable data. Söderstrom's native collectors in Ecuador wrapped but did not attach bands of paper with locality and sex data around their specimens, and these easily became mixed up, leading Chapman (1926:735) to comment ruefully: 'Inaccuracies of this kind cast a suspicion on all records which do not conform to the normal and thereby prevent papers based on native-made collections from adding much that is new to existing information in regard to distribution.' Leprosy forced the Penards, who assembled the first true series of bird specimens from Surinam, to rely on local collectors, and several species otherwise unknown from the country are represented in their huge egg collection, identified only by their assistants without confirmatory data (Haverschmidt 1955).

Louis Mandelli, a tea plantation manager in Darjeeling (Pinn 1985), provided local collectors with monetary advances, guns and ammunition, and (despite some abscondings and deceptions) thereby amassed a huge collection, by far the largest ever assembled in the central Himalayas. Unfortunately, the specimens have minimal data, such as 'Native Sikkim', 'Thibet', 'Bhotan Doars', no indication of altitude, and no safe indication of sex (Brooks 1880, Pinn 1985). It is furthermore possible that none of his specimens is really from Tibet, owing to the then-undefined borders (Vaurie 1972).

Many of Nepal's birds were discovered in the early nineteenth century by Brian Hodgson (Inskipp & Inskipp 1985), who was stationed (and under orders to remain) in Kathmandu and its Valley; thus he was obliged to rely on collectors (Cocker & Inskipp 1988). He took abundant notes and trained local artists to make coloured illustrations that serve as the types of many species (although by today's standards these would be considered *nomina nuda*). Now the country is relatively well known, but several of his species have not been found there again. This might be due to habitat loss, but so much uncertainty surrounds the exact provenance of some specimens (Cocker & Inskipp 1988) that an origin farther east cannot be ruled out. Even so, Hodgson's 'Nepal' material is less problematic than his later specimens labelled 'Behar' and 'India'. Those labelled 'India' by G. R. Gray (who in accordance with then current museum practice destroyed the original labels) are Himalayan; the preparation style is that of Hodgson's Nepal collectors, not his Indian ones; and they were independently considered by Thomas Moore to be from Sikkim (Horsfield & Moore 1854, Sharpe 1906:386).

A problem particularly acute in the Andes was the failure of some early collectors to record altitudes, for example with Salmon (Chapman 1917) and Söderstrom's collectors (Zimmer 1948:32). Reliance on local collectors often meant that specimens were labelled at a central point such as the camp, as with Söderstrom (Chapman 1926); in the cases of Buckley, Goodfellow and Hamilton even determination of the slope from which specimens came is impossible (Chapman 1926, Zimmer 1951b:35). Tibetan material from the 1924 Mount Everest Expedition was collected by local help, and nearly all the birds are labelled, without specific locality, as being from '10,000 ft', an unconvincing altitudinal uniformity (Vaurie 1972:68-69).

The reliability of testimony of local collectors can have major implications for conservation. Two twentieth-century examples come from Thailand. One concerns the almost mythical White-eyed River Martin *Eurochelidon sirintarae*, the only specimens of which are a small series supplied by local people in response to a broadcast appeal for live wild birds for ringing. According to Thonglongya (1968) the birds were trapped by throwing a net over reedbeds at Bung Boraphet, but a technical assistant subsequently reported that the birds were brought to the research team's hotel, so that neither the habitat nor the type locality can be entirely certain (P. D. Round in Collar 2001:1946-1947). However, the specimen labels have no indication of doubt as to the locality, thus lending false confidence to a provenance that is otherwise supported only by unconfirmed sight reports.

The second and more telling case, which could perhaps be treated under the heading 'Fraud' below, concerned what were for 50 years the last published records of Gurney's Pitta *Pitta gurneyi*, including the first recorded fledgling: these were supposedly collected at 600–1,060 m on the mountain Khao Phanom Bencha, in southern Thailand (Meyer de Schauensee 1946). These records went unquestioned until the compilation of all other evidence on the species led P. D. Round to perceive that, with the exception of these specimens, Gurney's Pitta is an extreme lowland specialist (Collar *et al*. 1986). Ultimately the species was relocated at this mountain, but only at its base; searches higher up were futile (see Collar 2001). As other exclusively lowland species were also represented in Meyer de Schauensee's 'montane' collection, it became apparent that his unaccompanied native collectors had not ascended the mountain, but had labelled specimens in the pretence of having done so (Round & Treesucon 1986, Round 1995).

Dealers and error

Commercial imprecision

The once-thriving business of dealing in natural history objects has long been a source of distrust among ornithologists. Several dealers (e.g. Argent, Turner, Maison Verreaux) were mentioned by Sharpe (1906) as having purveyed specimens with brief or inexact localities, and carelessness by an agent caused Sharpe himself to misattribute specimens in Sir Hugh Low's Bornean collection to the island of Labuan (Sharpe 1906:419). Commercial interests were often so much to the fore that accuracy over the provenance of material was neglected. The dubious origins of many of John Gould's specimens are attributable to such considerations, although perhaps no more so than those of his scientific contemporaries.

Among the most prominent dealers were Maison Verreaux of Paris, whose specimens found their way into numerous collections, and include type and important material for many taxa, which often appear to have acceptable localities. However, Lord Lilford observed them cavalierly assigning identifications for an egg collection (Trevor-Battye 1903, Mearns & Mearns 1998). A notable victim of such indifference to accuracy is the case of *Necropsar leguati*, whose unique specimen, labelled 'Madagascar', was acquired by Lord Derby from M. J. Verreaux in 1850. Aware that 'M. Verreaux was often very inexact in the precise geographical data he inscribed on the labels of his specimens', Forbes (1898) described it as a new species of starling from the Mascarenes, whereas recent examination reveals it to be an albino specimen of a mimid from the Caribbean (Fisher & Jackson 2002, Olson *et al.* unpubl.)! Many Verreaux specimens lack locality data, but bear large labels with elaborate writing, typically synonymies copied from Bonaparte's *Conspectus* (Sharpe 1906) and general localities (presumably the then-known range of the species) that could be misinterpreted as actual collecting localities.

Henry Whitely Sr: dependably undependable

The material stemming from Henry Whitely Sr is rife with problems. His son is well known for his collections from Japan, Peru and British Guiana (Haverschmidt 1955), although these were largely dispersed through his father's natural history agency (Sharpe 1906). However, many anomalous locality records have come to light based on specimens dealt by the father. These include records that, if credible, would be the sole ones from the Nicobar Islands for three species, White-fronted Falconet *Microhierax latifrons*, Purple-naped Sunbird *Hypogramma hypogrammicum* and Orange-bellied Flowerpecker *Dicaeum trigonostigma* (and, indeed, the sole records from the entire Indian subcontinent for the first two). Despite Whitely's insistence that his two *M. latifrons* specimens really did originate from the Nicobars (Gurney 1881), it is wholly improbable that this narrowly endemic Bornean falconet would occur in an undifferentiated form there. Furthermore, there are numerous other singleton specimens from Whitely Sr with localities that would be remarkable if true. Some have, however, been accepted in the literature, such as the NHM specimen of Japanese Sparrowhawk *Accipiter gularis* supposedly from 'Mhow', central India (Mees 1985a), and the NHM specimen of White-fronted Scops Owl *Otus sagittatus* supposedly from Aceh, Sumatra (van Marle & Voous 1988).

Among the entries of the Rothschild Collection in the AMNH catalogues, the localities of Whitely specimens are often surrounded by quotation marks, indicating that others were suspicious of his often very general localities such as 'Java', 'Nepal', 'NW Australia', 'New Zealand', etc. Tristram's (1889) catalogue contains a listing of a Whitely specimen of Pied Lapwing *Hoploxypterus cayanus* (= *Vanellus cayanus*) from Chile, a country from which it is not genuinely known. A Whitely skin of Purple-bibbed Whitetip *Urosticte b. benjamini* from 'Rio Napo' is the 'wrong' race for the eastern side of the Andes (Zimmer 1951a), and the 'Tinta' locality of a Whitely specimen of Purple-collared Woodstar *Myrtis fanny* is anomalous (Zimmer 1953a). The sole basis for the inclusion of Lesser Swallow-tailed Swift *Panyptila cayennensis* in the Peruvian avifauna is a Whitely skin from 'Samiria' (Zimmer 1953b). Two Whitely *Terpsiphone* specimens labelled as from 'River Gambia' formed the only basis for a new species *T. erythroptera* (Sharpe 1879); however, the specimen was almost certainly a mislabelled Asian Paradise Flycatcher *T. paradisi* (Sclater 1930, Warren & Harrison 1971, F. Salomonsen in Traylor 1986). Numerous other similar problems with Whitely provenances continue to surface.

Not even Whitely specimens labelled 'British Guiana', where Whitely Jr collected extensively, are free of problems. The race *Iodopleura pipra leucopygia* of this otherwise Brazilian species, Buff-throated Purpletuft, was described (Salvin 1885) on the basis of Whitely skins labelled 'British Guiana', but it has never since been found there—unsurprisingly, since this is within the range of a congener (Snow

1982). Whitely Jr's Guianan collecting took place subsequent to the collecting of the *Iodopleura* specimens, which are in a trade skin style, so they seem to be mislabelled (Snow 1982). Furthermore, birds matching race *leucopygia* have since been observed in Brazil (Ridgely & Tudor 1994).

Even more significant is the case of the Scissor-tailed Hummingbird *Hylonympha macrocerca,* named from a specimen bought from Whitely Sr, who had 'received it in a collection of skins which had been formed in Brazil' (Gould 1873), apparently purchased at London Docks (Boucard 1892-1895). More specifically, Simon (1921) recorded that Whitely had given Gould the definite locality 'Matura district, Manawas, on the Bia River, north Brazil'. However, this spectacular species, imported in good numbers by dealers and with all specimens being in the 'Trinidad' style (see below), has never been found in Brazil. Instead, almost 75 years after its description, *H. macrocerca* was finally located in the montane zone of the Paria Peninsula, Venezuela (Phelps & Phelps 1948), to which it is now known to be endemic (see Collar *et al.* 1992).

Misattribution to commercial entrepôts

For many years, countless thousands of exotic bird specimens were collected by locals, who were mostly trained to prepare them for the insatiable European and North American millinery markets. These collectors typically produced specimens of a recognisable preparation style, such as 'Trinidad', 'Bahia', 'Rio' and 'Bombay', obviously named for the point of collection and shipping. Natural history dealers and scientists often scoured incoming shipments for unusual species. Most numerous was the 'Bogotá' make, which some have assumed to come from the environs of the city of Bogotá—as did Vaurie (1967) with a specimen of Blue-knobbed Curassow *Crax alberti* (Collar *et al.* 1992)—when in fact specimens were brought from all over the surrounding country, probably even outside the borders of present-day Colombia and from the far slopes of the Andes (Parkes 1969). Some alleged 'Bogotá' specimens must have come from even farther afield, such as Sickle-winged Nightjar *Eleothreptus anomalus* (Knox & Walters 1994). A great many 'Bogotá' specimens were hummingbirds, and some are still known only from such trade skins of uncertain provenance (Chapman 1917, Graves 1990, 1997). Similarly, trade skins from adjacent Ecuador were often labelled either 'Napo', meaning any elevation on the Amazonian side of the Andes, or 'Gualea', meaning the equivalent on the Pacific side (Chapman 1926).

'Malacca' is a very common 'locality' for specimens from a long-standing trading mecca where skins were brought, probably from the entire western seaboard of the Malayan Peninsula (Gibson-Hill 1949) and even farther afield, but which matches a present-day provincial town. Medway & Wells (1976) rightly questioned distributional and migration conclusions based on 'Malacca' trade skins of Japanese Sparrowhawk *Accipiter gularis*, while Mees (1985a) defended the specimens as acceptable. Other trade-skin localities in the Malaysian region included Penang and Singapore (Gibson-Hill 1949). A subspecies of Common Scops Owl, *Otus scops* *obsti*, was described from a skin labelled 'Java' (Eck 1973), but the type and only specimen, indistinguishable from dark Sulawesi Scops Owl *O. manadensis* of Sulawesi, bears only a dealer's label and seems most unlikely to represent a valid taxon (Rasmussen 1998, unpubl.). Another major trade point was the port of Menado, in northern Sulawesi. A specimen labelled 'Menado' was named *Rhipidura lenzi* Blasius 1883, but was soon shown to be from Ambon (Forbes 1884) and subsequently synonymised with the form *cinerea* of neighbouring Seram (Stresemann 1914, White & Bruce 1986).

The make of trade skins has sometimes allowed them to be 'identified' by experienced museum workers to a general region (e.g. 'Demerara', 'Bahia', 'Cayenne'), but usually without explanation of how they differ or the levels of certainty. For example, Zimmer (1950:30) stated without elaboration that a bird labelled 'Peru' is of undoubted 'Cayenne' make. Occasionally, specimens of genuine provenance may be taken for trade skins. The Moluccan Scops Owl *Otus magicus morotensis* is an example: numerous old specimens are labelled as being from Ternate, a Moluccan port with little forest, and the base of operations for the dealer Bruijn (Greenway 1973). The scops owls had been considered of doubtful provenance, but they form a series recognisably different from those of other islands (including Morotai, with which they are still combined racially), and a recently collected specimen confirms their Ternate provenance (PCR unpubl.).

Collections personnel and error

Assumption, accident and incompetence

Some treatments and interpretations by museum staff and ornithologists have inevitably resulted in confusion and mistakes with respect to specimen evidence. As noted earlier, we do not dwell here on misidentification of specimens, an inevitable part of curation, but there is clear thematic overlap here with the earlier discussion of data-poor specimens.

Because of problems with the localities of older specimens, these can sometimes be discredited prematurely when they do not seem to fit with current data. The type locality of the Brown Cacholote *Pseudoseisura lophotes* is 'Bolivia?', which subsequent authors presumed to be incorrect, although specimens are now known from the country (Parkes 1960). The type locality of *Formicivora deluzae*, a taxon of uncertain affinities to the White-fringed Antwren *F. grisea*, was judged doubtful because of other mistakes in Ménétries's paper; only later did it become evident that it may well be correct (Gonzaga & Pacheco 1990). Lack of records for a century after the collection of Flores Scops Owl *Otus alfredi* in western Flores led to the view that it was only the rufous morph of *O. magicus albiventris*, precipitating the removal of *alfredi* from lists of threatened species; but close re-examination of specimens vindicated the original data (Widodo *et al.* 1999). Information *in litt.* from O. Neumann led Peters (1945) to substitute the Sula Islands for Makassar, Sulawesi, as the type locality of the Ruddy Kingfisher *Halcyon coromanda rufa*, but re-examination showed Neumann to have misinterpreted the evidence (Mees 1991). A specimen of White Bellbird *Procnias alba* collected by A. R. Wallace during his historic trip to Belem seemed so far out of range that the record was omitted by Snow (1973), but a population has now been discovered there (Roth *et al.* 1984, Oren & Novaes 1985).

Genuine localities written on labels may also misrepresent the circumstances of the provenance of specimens in other ways. A notable case is a specimen of Grey-faced Buzzard *Butastur indicus* from Sri Lanka, which would have been the first record for that country and the only specimen for the Indian subcontinent. Enquiries established that both the collector and the specific locality were known and presumably reliable, but the chance discovery of an old photo of a *Butastur* in falconer's jesses prompted re-examination of the specimen for signs of captive origin—and indeed it bears signs of having been kept both on a tether and in a pen (PCR unpubl. data).

Carelessness to the point of serious professional incompetence was shown by the taxonomist G. Mathews. He erected an amazing number of new taxa (most now in synonymy) on the most tenuous of grounds. For example, he obtained a number of birds from Gerrard, the London dealer, labelled from 'Mackay, Queensland', from which he described several subspecies, usually bestowing a variant of the locality name on them (Greenway 1973). In one case he later synonymised *Globicera pacifica queenslandica* with the nominate, listing the locality as 'error = Tonga Islands'. His *Ninox rufa queenslandica* remains unique to the area, and the locality has been doubted (Greenway 1978). Mathews named a new species of cuckoo *Cuculus waigoui* (now a synonym of migrant Oriental Cuckoo *C. saturatus*) from a specimen said to have been collected on Waigeu Island in February. He named many new procellariiform taxa, typically surmising on slender or no evidence the natal grounds of birds collected at sea. He named a 'NW Australia' Soft-plumaged Petrel *Pterodroma mollis* specimen (obtained as a duplicate from NHM) as a new species, then synonymised it with the assertion 'locality wrong', despite the fact that the species occurs widely as a vagrant (Greenway 1973). From a series of Lord Howe *Fregetta* he erected four new species, three of them from single specimens (Greenway 1973). Many of Mathews's specimens have no original label, so that their provenance cannot be independently evaluated (Greenway 1973). Indeed, Greenway (1973) was routinely unable even to endorse characters and measurements specifically mentioned by Mathews as applying to his type specimens.

Label substitution

Even the most scrupulous collectors could not guard against events that might befall their specimens in the hands of others. For many years it was standard practice for curators, among them some of the most respected names in ornithology—G. R. Gray at NHM (Sharpe 1906), O. Finsch at RMNH (Mees & Fisher 1986), R. Ridgway at USNM (Deignan 1961)—to discard original labels after copying the data they considered relevant onto labels of their own collection. These removals mean that it is now impossible to verify spellings, handwriting or other details for affected specimens, or even to determine whether they ever bore original data. Thus Finsch's recopying and discarding of Layard's label on a Lifu Island Thrush *Turdus poliocephalus pritzbueri*, with an error of date, meant that the specimen was likely to have been erroneously considered a type, and indeed it was so labelled by Finsch (Mees & Fisher 1986).

Another case concerns von Rosenberg's Leiden specimens, whose original labels were removed by Finsch (Mees 1953). Von Rosenberg's travels are comparatively well documented (van Steenis 1950), and the dates of his specimens can be checked against his itinerary. However, his series of *Zosterops atrifrons* '*sharpei*', supposedly from the Aru Islands (and the only material of this questionable race, described by Finsch), is identical with the nominate race of Black-crowned White-eye from northern Sulawesi (Mees 1953). Moreover, von Rosenberg supposedly—and uniquely—procured a specimen of the extremely restricted Pearl-bellied White-eye *Zosterops grayi* on the Aru Islands (Mees 1953); and he apparently took three Moluccan Scops Owls *Otus magicus* there too, a provenance accepted by most authors though they were suggested by White & Bruce (1986) to have come from the Kei Islands. In this last case, although *O. magicus* is well differentiated with recognisable forms on each island group, the lone adult of the three is indistinguishable from the nominate race of Seram and Ambon, and the juveniles unidentifiable (PCR unpubl. data). Given the considerable confusion between other of von Rosenberg's Aru and Kei specimens, e.g. Pied Imperial Pigeon *Ducula bicolor*, Orange-fronted Fruit Dove *Ptilinopus aurantiifrons*, Red Lory *Eos bornea* and Chestnut-breasted Cuckoo *Cuculus castaneiventris* (= *Cacomantis castaneiventris*) (Holyoak 1970, 1976, White & Bruce 1986), all these records are dubious. Indeed, the provenance of von Rosenberg's specimens had been doubted by Salvadori (1880-1882) well before Finsch's removal of the original labels around 1900, so they seem likely to have previously borne questionable data. Von Rosenberg employed local collectors, and at least sometimes sent them collecting while he himself was ill (van Steenis 1950); he collected in Sulawesi, the Arus and Keis on the same voyage, so the specimens could easily have become mixed, a scenario rendered all the more likely given his characterisation as an 'idler' (van Steenis 1950) and the description of his collection as being of little scientific worth (von Berlepsch 1913).

A similar case is that of the lone specimen of Ambon Yellow White-eye *Zosterops kuehni* from Seram, labelled as having been collected by Moens on the side of Seram farthest from Ambon, to which the white-eye is otherwise thought endemic. While several authors have thought it unlikely that Moens really obtained *Z. kuehni* on Seram, letters show he collected there, and it seems impossible to disprove a Seram origin (Mees 1981, R. W. R. J. Dekker *in litt.*). Often, however, reference to a collector's known itinerary can solve mysteries: by this means a published record of Bare-faced Curassow *Crax fasciolata* from Obidos (Pinto 1938), which seemed to indicate range overlap with Black Curassow *C. alector*, was shown to be an error caused by the loss of the original label (Pinto & de Camargo 1948).

Label-switching has been assumed in a number of cases, although it is usually difficult to prove (e.g. Watson 1969, Farkas 1979, Cardoso da Silva & Oren 1991). Compounding this, over the years labels occasionally fall off and are retied, inevitably sometimes to the wrong specimen, even of another species—e.g. a Siberian Crane *Grus leucogeranus* bearing also a White Wagtail *Motacilla alba dukhunensis* label (Knox & Walters 1994)—and many labels have been and continue to be irretrievably damaged, lost, or rendered illegible. A mysterious 'species' of rail (*Tricholimnas conditicius*), suggested to have originated either on the Gilbert or Marshall Islands (Peters & Griscom 1928, Walters 1987), has been shown most likely to have been erroneously associated with a label that led to those conclusions, but in fact to be a synonym of the Lord Howe Wood Rail *Tricholimnas silvestris* (Olson 1992).

A typical loss on recopied labels was the frequent omission of the collector's own numbering system. However, collectors' numbers, often involving a simple sequence related to date of collection, can provide critical evidence as to provenance of a specimen. LeCroy & Peckover (1998) showed, through archival research and reference to the original collector's still-present number, that a subset of a substantial series of specimens taken by A. S. Meek on 'Misima Island' off Papua New Guinea had actually been collected from neighbouring islands during the main Misima collecting trip.

The simple fact that a specimen does not now bear confirmatory data does not mean that such data never existed. White (1975) stated that W. Rothschild assigned localities to dataless cassowaries based on preconceptions over the distribution of their phenotypes. It it true that Rothschild ventured to describe a market-bought specimen of Grey-headed Albatross *Diomedea chrysostoma* as a new race he presumed to be from Campbell Island (Hartert 1926). However, White did not present sufficient evidence to support his contention, and Rothschild, who was normally reasonably careful with localities, may well have had correspondence and other information that led him to reasoned assessments, if not watertight facts; unfortunately, many of his potentially corroborating papers were destroyed following an ill-taken official decision (M. Rothschild 1983).

Various users and error

Problems in transliteration, translation, interpretation and reading

Misreading and misinterpretation of label data occur frequently, and have accounted for a great deal of error: 'Iris Brown' has been catalogued as a collector (D. E. Willard *per* N. J. Collar verbally), and 'Mr Fernando Poo' as a donor (F. E. Warr verbally); 'Mr. Kaitsumwic', a supposed collector of *Podiceps ruficollis japonicus*, proved to be a mutilation of the Japanese name for 'grebe' (Greenway 1973); 'Vorondolo' is a traceable locality in the eastern rainforest of Madagascar from which a specimen of the Malagasy Scops-owl *Otus rutilus* so labelled may plausibly have come, but is also one of several Malagasy names for owl (PCR unpubl.); and 'Kinkimauro' was published as a locality for Pollen's Vanga *Xenopirostris polleni*

(Sharpe 1872) when again it is the local name of the species (Collar & Stuart 1985:430). Pollen's Vanga was also the victim of an error over the type locality by Hartlaub (1877), who published it as north-east Madagascar, evidently because he assumed 'N.O. Madagascar' on the labels of the type series to indicate 'nord-öst' (German north-east) rather than 'nord-ouest' (French north-west) (Collar & Stuart 1985:430). Certainly, foreign-language labels are particularly prone to misinterpretation: Banko (1979) apparently mistook the notation 'Erh[alten] von Chili' ('taken in Chile') for a collector's name (Olson 1989), and 'Enero' (=January) has been used as a locality (S. L. Olson verbally).

A locality written on an Abyssinian Thrush (subsumed into Olive Thrush) *Turdus abyssinicus* label as Entebbe, Uganda, actually refers to N'dabibi (Cunningham-van Someren & Schifter 1981). This mix-up may have been due to poor handwriting, hearing, and/or transcription. The first category is the easiest to document: the untraceable 'Muguazi River' as the type locality of Black-cheeked Lovebird *Agapornis nigrigenis* has been shown to be the Ngwezi River (Dowsett 1972a); the locality 'Sandag, Sarigas' (Seth-Smith 1910) for Philippine Eagle *Pithecophaga jefferyi* is in reality 'Tandag, Surigao' (Collar 2001:672); and, most strikingly, J. Natterer's locality 'Tacuczar' is, *fide* Vanzolini (1992), 'Itacuruca'.

In the field in Myanmar in 1985, PCR's enquiries as to the place name at which the team was collecting resulted in helpful replies, dutifully copied down—one of which turned out to mean 'little stream'. According to J. P. Angle (verbally), D. S. Rabor sometimes took students collecting with him in the Philippines, but some 'localities' written on the labels appeared to be students' home addresses.

Units of measurement

One of the most obvious and yet pervasive problems involving collection dates is the dichotomy between British and American styles of writing dates on labels. One of the seven specimens of Forest Owlet *Heteroglaux blewitti*, that accessioned to MCZ, had the (British) collection date ('5/12', hence 5 December) interpreted in the American fashion (hence 12 May) on the MCZ label (Rasmussen & Collar 1999a:12). In this particular case the species seems to be resident, and so the seven-month disparity matters mainly in study of the plumage cycle, but for many other species such an error would place them far from their normal haunts for that time of year. One specimen in NHM, a House Wren *Troglodytes aedon guadeloupensis*, now bears three label dates (Knox & Walters 1994), evidently at least in part owing to the use of roman numerals for months (II = 2 but easily read as 11).

Numerous specimens lack collection dates on the labels, but may have a date of acquisition by a dealer or accession by a museum that is not stated as such, e.g. a Snail-eating Coua *Coua delalandei* bearing the date 1837, which is the date of its receipt in Stuttgart (Benson & Schüz 1971). Darwin's bird specimens collected during the voyage of the Beagle had labels inscribed "Jan 4th 1837" added to mark the date they were accessed by the Zoological Society, not the date of collection (Sulloway 1982a,b).

Another persistent problem is that of distances, whether kilometres *vs* miles, metres *vs* feet, or millimetres *vs* inches. It has often been taken for granted by collectors that their units would be understood, which has of course not always been true. Several standards of measurement existed within Europe in the past, and are briefly discussed by Zimmer (1947).

Mis-sexing and ageing

Assumptions are often made about sex and age in birds, but museum specimen data cannot be taken as definitive without detailed corroboration. For many older specimens, it may be that the collector did not actually view the gonads when determining the sex. Some collectors operated in an assembly-line fashion, and are reputed to have crossed the legs one way to indicate one sex, and vice versa, a system that cannot fail to produce the occasional error. Early collectors often used an upside-down female symbol to indicate male (Clench 1976, Parkes 1989), which is open to misinterpretation by modern researchers. Collectors whose specimens are *always* sexed can be assumed to have been less careful than they might, as a certain proportion of specimens, especially when shot, will not be confidently sexable. Breeding-condition individuals of most species (a few exceptions are noted below) would rarely be mis-sexed when the gonads are examined, but juveniles and non-breeding birds are subject to unknown and variable, but presumably often significant, rates of mis-sexing. Users of specimens need to consider the field conditions that influence accuracy of sexing, such as poor lighting; exhaustion, illness, and/or training of the preparator; and development or deterioration of the specimen's gonads.

Statements made about sexual dimorphism based on circuitous reasoning led to the belief that the presumed taxon *Psittacula* '*intermedia*', alone among its congeners, had reversed sexual dimorphism (Sane *et al.* 1987). This helped obscure the hybrid origin of '*intermedia*' (Rasmussen & Collar 1999b). Mis-sexing and/or incorrect ageing is also held responsible for some of the apparently distinctive characters of the Moustached Kingfisher race *Halcyon bougainvillei excelsa* (du Pont & Niles 1980).

A few groups of birds have atypical gonads, such as female accipiters, which have two readily visible ovaries, and *Centropus* species in which the males have only one large testis. Members of these groups are obviously more likely to be mis-sexed than those with conventional gonads. Knox & Walters (1992) documented mis-sexing in nearly 15% of Eurasian Sparrowhawk *Accipiter nisus* skeletons checked in the NHM, a surprising percentage given the gender-specific plumage and size of this species; Storer (1989) obtained similar results for skins of the highly size-dimorphic Brown Trembler *Cinclocerthia ruficauda*. RPP-J's own first venture into the NHM collections was prompted by a contradiction between Witherby *et al.* (1943) and Svensson (1970), who respectively maintain that there is complete overlap and no overlap in the wing lengths of male and female Corn Buntings *Emberiza calandra*, a species that shows no sexual plumage difference. Scrutiny of over 40 NHM specimens that would have been available to Witherby *et al.* suggested that nearly

20%, all taken outside the breeding season, had been mis-sexed, obscuring an almost complete sexual size difference (Prŷs-Jones 1976).

Even in species that are strongly sexually dimorphic from their first contour plumage, e.g. Rufous-bellied Niltava *Niltava sundara* (Dickinson 1972), the incidence of apparent mis-sexing may be high. All the specimens of Greenish Puffleg *Haplophaedia aureliae* collected by Goodfellow and Hamilton were shown to have been mis-sexed (Zimmer 1951b:35), suggesting they relied upon the plumage of this drab hummingbird for gender determination. Some scrupulous nineteenth-century collectors (e.g. A. Everett) as a matter of course wrote 'nat. coll.' or its equivalent on the labels of specimens sexed by their assistants and which they had been unable personally to verify.

Ageing of specimens can be notoriously problematic, and many taxonomic blunders have resulted from misinterpretation of specimen ages, e.g. 'Berlioz's Sunbird' *Anthreptes pujoli* is actually a a juvenile Green Sunbird *Anthreptes rectirostris* (Erard 1979). The new genus and species *Antiornis grahami* Riley 1926 was described from a series of juvenile specimens which Parker (1964) and Watson (1986) considered to be Aberrant Bush Warblers *Cettia flavolivacea* , but which are actually Brownish-flanked Bush Warblers *C. fortipes* (Rasmussen & Anderton, in press). Even the routinely used notation of cranial ossification has its limitations, as the extent of cranial pneumatisation in full adults of many species is not known with certainty; for example, in *Pipromorpha* only a small part of the cranium appears to ossify (Mees 1985b), and incomplete ossification in adults has also been noted for numerous other species (Winkler 1979).

Fraud

There are a few cases within ornithology that seem to amount to major specimen fraud, but it is often difficult to be certain whether the perpetrators realised the consequences of their actions. Thus it is unclear exactly in what category some of the examples below belong.

The classic case of apparent fraud, less for its intrinsic importance than the wider publicity it received, was the 'Hastings Rarities' (Nelder 1962, Nicholson & Ferguson-Lees 1962, 1971, Harrison 1968, 1971), in which records of birds rare to Britain purported to have been collected mostly by anonymous locals within a 20-mile radius of Hastings were traced to the dealer and taxidermist G. Bristow, who was suspected of having had them brought over from the Continent under refrigeration (Nicholson & Ferguson-Lees 1962). Consequently, in 1962, six species and some 600 (mostly specimen) records of rarities, made in the Hastings area between 1892 and 1930, were removed from the British list, based on the statistical improbability of so many unusual records clustering in so small an area, plus the fact that the great majority had links to Bristow. Bristow had claimed that he had encouraged local people to shoot specimens for him, whether they were common or not; that the sheer numbers of specimens sold to him resulted in the large number of rarities over the years; and that anonymity was necessary to protect his sources from competitors and prosecution. If we accept that the Hastings Rarities are indeed fraudulent, the reason must presumably have been monetary gain, which is probably true of most situations in which deliberate specimen fraud has been perpetrated.

Much collecting in earlier days was conducted as a commercial enterprise in which the value of specimens was directly linked to their scarcity, either in total or from a particular area. J. H. Batty, working on islands off the west coast of Panama, duped his employer Rothschild by adding mainland (including highland) birds to island collections, and although Hartert caught on at least once, Eisenmann (1950) did not, and reported on Batty's 'surprising number of what have generally been regarded as exclusively mountain birds'. Wetmore (1957) puzzled over discrepancies relating to some of the specimens Batty had collected on the large island of Coiba in 1901 and assumed a specimen mix-up, but Olson (1997) recently concluded that Batty's entire supposed collection from the smaller islands in 1902, including such astonishing records as male Ruby-throated Hummingbirds *Archilochus colubris* with nests, is fraudulent and, indeed, that Batty probably never even visited these islands in 1902.

A collector working in Venezuela for W. Rothschild, A. Mocquerys, was long suspected by Hellmayr and others of having provided unreliable localities for a rather long list of species (Zimmer & Phelps 1954). These authors concluded that Mocquerys's lack of success on a Caripe trip led him to augment it with specimens from Puerto Cabello, where operations were cheaper and easier, a conclusion supported both by Mocquerys's written complaints to Rothschild and by irregularities in field numbers in his 'Caripe' series (Zimmer & Phelps 1954).

Among the most prolific of all collecting teams in the Neotropics, the Olalla family had already been collecting birds professionally when contracted by Chapman. Their collections are of extreme importance for understanding avian distribution within South America. Usually their labelling seems reliable, apart from being ambiguous over which side of a river material was from, and the occasional lapse, e,g. their taking of five specimens of Sharpbill *Oxyruncus cristatus* on a single day at a lowland site from which it was previously unknown, was assumed to reflect failure to label specimens accumulated earlier upstream (Mees 1974). However, Vaurie (1965) rejected A. M. Olalla's specimens of Little Chachalaca *Ortalis motmot ruficeps* supposedly collected within the exclusive range of the nominate race, adding that other naturalists have queried the authenticity of some Olalla material. Moreover, a small proportion of Olalla specimens appear actually to have been fraudulently labelled during a dispute; these include specimens sold to H. Bassler and now at AMNH (J. Haffer verbally).

Egg collections present special problems owing to the difficulty or impossibility of certain identification. In particular, it should be mentioned that the largest collection of Indian bird eggs ever assembled, that of E. C. S. Baker, which serves as the basis for much of our presumed knowledge of the eggs and nesting habits of Indian birds, is seriously flawed. Even discounting the difficulties of identification and the problems involved with employing native collectors, serious charges of the 'making up' of clutches in Baker's collection have been levelled (Harrison 1966, Harrison & Parker 1966, 1967a,b). Egg collections also have been subject to massive theft by enthusiasts (e.g. stolen eggs of numerous rare species: Knox & Walters 1992, 1994). In the case of the Bald Eagle *Haliaeetus leucocephalus*, eggs with false registration numbers had been substituted for the stolen ones (Knox & Walters 1994). One documented case of specimen fraud is a painted Mute Swan *Cygnus olor* egg now in the NHM that was passed off by a dealer as a genuine Great Auk *Pinguinus impennis* egg (Tomkinson & Tomkinson 1966).

Meinertzhagen

The fraudulent collecting activities of one person, Richard Meinertzhagen, form a subject apart both in scale and, probably, motivation. His case also reveals how slow and difficult the path may be from well-founded suspicion to a reasonable level of proof and how, in the intervening period, most researchers using a collection may remain entirely ignorant of the doubts surrounding the data accompanying it, with negative effects on ornithology. However, on the positive side, the case has also proved to be one in which detailed research is allowing original data to be restored to specimens with a high degree of probability, and which has even led, indirectly, to the rediscovery of a supposedly extinct species (King & Rasmussen 1998). In our discussion here we draw on various sources for general background information, notably Cocker (1989) and Rasmussen & Prŷs-Jones (unpubl.).

The collection Meinertzhagen presented to The Natural History Museum (NHM) before his death in 1967 amounts to nearly 20,000 specimens, with appreciable additional numbers of specimens held in other museums. In the Meinertzhagen Collection are numerous important distributional records. Although born in 1878, Meinertzhagen's first significant publication dates from as late as 1912, on the birds of Mauritius, where he had spent about a year in 1910–1911; the paper contains almost no mention of specimen collecting. By 1919, however, Meinertzhagen had already been excluded from the NHM Bird Room for 18 months for unauthorised removal of specimens, and museum documents spanning the next 30 years contain numerous references to suspicions by staff that he was stealing both specimen and library material; twice these reached the verge of prosecution. Although nothing was made public, clearly at least some senior ornithologists knew that something was amiss. Around 1940, correspondence between H. Whistler and C. B. Ticehurst makes explicit reference to Meinertzhagen's theft of NHM specimens. However, no mention of this reached the published literature until 17 years after Meinertzhagen's death, when Clancey (1984a), who had developed a deep antipathy to Meinertzhagen, drew attention to the flawed nature of his collections. The accusation of fraud was made explicit in a review of Meinertzhagen's redpoll specimens, based on assessment of preparation style and material used (Knox 1993). While compelling, the implications of this paper were so enormous that independent corroboration and further investigations were clearly demanded.

In the case of the redpolls, further research making use of x-rays (radiographs) has largely confirmed Knox's conclusions, although occasionally it has shown up limitations in what is discernible by external examination alone (RPP-J unpubl.). While it cannot be claimed that x-rays can prove who collected a specimen, the x-ray specimen signature of many major collectors is extremely distinctive. In many cases, not only can the fraudulence of a specimen be shown beyond reasonable doubt, but the original data can also be returned to a specimen with a high degree of confidence through the location of gaps in matching specimen series that were recorded in the NHM specimen registers.

In order to judge the scope of the problem, we have examined a large number of Asian bird specimens in the Meinertzhagen collection, in particular focusing on key cases such as at least 14 species and distinctive subspecies on the Indian subcontinent list based entirely on his records. We have found that the scope of the problem is far greater than that so far published by Rasmussen & Collar (1999a); a comprehensive analysis, on which we draw here for examples, is in preparation (Rasmussen & Prŷs-Jones unpubl.).

Meinertzhagen had a seemingly miraculous ability to stop very briefly somewhere but nevertheless collect important material. When his ship unexpectedly docked in February 1901 at Port Blair, Andamans, en route to Burma, he claimed he rushed off to collect birds behind the town. However, of his good Andaman series, all supposedly taken by him during this brief time, we have yet to find any specimens that appear to be genuinely his. For example, his single Andaman Treepie *Dendrocitta bayleyi* matches in every detail, both externally and internally, two specimens collected there by William Davison in 1872, including having an unusual neck support in lieu of a stick, and a distinctive under-the-wing incision, just like that of Davison's specimens. The NHM registers show that a third Davison specimen, collected in the same week as the other two, is now missing.

Similarly, Meinertzhagen's ship stopped briefly in the Seychelles in June 1910 and his collection now holds two specimens of the extremely rare Seychelles Paradise Flycatcher *Terpsiphone corvina*, both with the locality given as just 'Seychelles'. These have the same make and materials as an NHM Nicoll specimen taken on Praslin, Seychelles, in 1906. The NHM register reveals that three adult males collected by Nicoll were accessioned, but only one (with detailed data) is now present in the collection. The other two Nicoll specimens, which probably also once had full data, had been earlier and independently noted as missing by Benson (1971). Moreover, Meinertzhagen's ship docked at Mahé, where the paradise flycatcher does not occur, and according to his diary and itinerary it was present too briefly for Meinertzhagen to have visited the islands the species did inhabit.

Many of Meinertzhagen's frauds have potentially important zoogeographic implications. Among his substantial collection supposedly made in Burma in 1902 are two specimens of the scarce and little-known Blyth's Kingfisher *Alcedo hercules* prepared in dissimilar styles. One of these is very similar in style to an 1899 Whitehead specimen from Hainan, China; the NHM register shows that two such Whitehead specimens were originally present, but only one now is. The other specimen matches no NHM specimens, but closely matches a series of three taken on Hainan by Owston's collectors in 1905–1906 and now in the Rothschild Collection at AMNH; according to Hartert's (1910) paper on Owston's collection, this originally held four specimens. Thus both Meinertzhagen's 'Burma' specimens are evidently from Hainan, some 1,500 km to the east of the purported locality, and with considerable potential to obfuscate knowledge of geographic variation in a scarce species represented by relatively few specimens.

Occasionally, and notoriously in the case of the exceptionally rare Forest Owlet *Heteroglaux blewitti* (Rasmussen & Collar 1999a), Meinertzhagen had extensively remade an existing specimen in a manner which served to disguise its true origin until detailed examination, including forensic tests, was made. This particular case had a doubly positive outcome, as not only was the specimen—one of only seven of the species in existence—identified as a J. Davidson specimen stolen from the NHM and finally reunited with its original data, but the investigation led directly to the rediscovery of the Forest Owlet 113 years after the last reliable record.

Most Meinertzhagen specimens have basic locality, date and sex data, but some labels contain additional information. For example, a skin of Gould's Shortwing *Brachypteryx stellata* that is almost certainly a stolen Mandelli specimen now has soft-part colour and stomach contents annotated on the label, even though of the thousands of Mandelli's native-collected specimens we have seen none that bears any such data, indicating these must have been guessed at by Meinertzhagen. Similarly, a Black-billed Magpie *Pica pica bottanensis*, supposedly collected by Meinertzhagen 'on a yak!' in 1925 along the Sikkim–Tibet border, closely resembles a Mandelli specimen from Tibet in make-up and structure, to the extent that both are (most unusually) stuffed with moss easily visible in the unsewn belly incisions. In addition, in his own account of his Sikkim expedition, published within two years of his expedition, Meinertzhagen (1927) specifically noted that 'No magpie was met with in northern Sikkim', so he evidently forgot he had written this when relabelling the specimen, presumably some time later.

In addition to the many spurious distributional records published by Meinertzhagen himself on the basis of his mislabelled specimens, others have been published in good faith by other workers, among them Pallas's Bunting *Emberiza pallasi* as new for Burma (Colston 1978), Savi's Warbler *Locustella luscinioides* as new for Arabia (Colston & Holyoak 1970), and a range extension for Mottled Spinetail *Telecanthura ussheri benguellensis* (Benson & Winterbottom 1977). A Meinertzhagen Half-collared Kingfisher *Alcedo semitorquata* was considered probably mislabelled, as the locality he gave would have been a swamp instead of the species's normal clear riverine habitat (Clancey 1984b). Meinertzhagen (1930) reported that Sooty Falcon *Falco concolor* bred regularly at Mombasa Fort, but this casual, unconfirmed record is so greatly at odds with the observations of others that it was not usually accepted (Moreau 1969) even before the exposition of Meinertzhagen's frauds.

Despite all these problems and many more, it is clear that much of Meinertzhagen's collection comprises important specimens bearing genuine data. In particular, either the preparation style of someone who is known to have accompanied Meinertzhagen on a particular trip, or the presence of that collector's handwriting on a label, point to a given specimen being genuine. A case in point is Meinertzhagen's unique South Yemen specimen of Northern Bald Ibis *Geronticus eremita*. We know that P. A. Clancey was on this 1948 trip, and the specimen was prepared in his style and with his unmistakeable handwriting on the label, so it is difficult to imagine how this specimen could be other than genuine. Further important specimens from the Meinertzhagen Collection that we are confident are genuine include his type series of Afghan Snowfinch *Montifringilla theresae*. He discovered this species in 1937; the series has all the hallmarks of authenticity, and no other source existed for them. Similarly, our initial suspicions about his two Hume's Owl *Strix butleri* specimens (considered among the highlights of his collection) were allayed by the fact that both still bear their original labels with full data, and Meinertzhagen had not claimed to have collected them himself.

Other indications (to be used advisedly!) that a series purported to be from a given trip in the Meinertzhagen collection may be genuine include: presence of some females and immatures; some specimens being in imperfect plumage; uniformity of preparation style; seasonally appropriate moult condition and soft-part colours; and a lack of reworking of the specimen. In fraudulent material the latter is often evident as a loosely restitched abdominal incision with double thread, fresh clean cotton in belly and eyes, and legs that were crossed well after drying, often breaking delicate bones and twisting the dried skin.

Given that the Meinertzhagen Collection contains material of great importance, and that the original data from fraudulent specimens can often, with some research, be repatriated with high confidence, we disagree with a former NHM curator with first-hand experience of Meinertzhagen, who stated that the entire collection should be destroyed. Without the specimen evidence, suspicion regarding Meinertzhagen's records might never have been made public. Moreover, there would certainly have been no way, many years later, to establish which records are genuine and which fraudulent, and to restore the correct data to at least some of the latter.

Conclusions

We do not wish to leave the reader with the impression that specimen data are unreliable. On the contrary—the vast majority of specimens provide the most reliable source of baseline data available in ornithology. However, specimen evidence must be assessed probabilistically. The user needs to be aware of the exceptions and to be informed as to how to evaluate individual problem cases. It is not sufficient simply to throw out specimen data as unreliable because they do not fit one's hypotheses or the published record. Corroborative evidence should be sought, and there are many ways to seek it. In any particular case the reliability of associated data can often be tested in various ways.

The specimens that exist now in museums are largely irreplaceable. Many of them have been mistreated in various ways, usually by well-meaning collectors, dealers, curators and users. Those who are responsible for the care of specimens and who may consider certain material worthless, for example if data are lacking, should reconsider this stance in the light of the potential for data recovery using combinations of historical reconstruction and modern analytical techniques. A dataless specimen may turn out to be something as valuable as the unique type of the Mysterious Starling *Aplonis mavornata* (Olson 1986), even if it takes 160 years for someone to recognise the fact.

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The archive and the ark: bird specimen data in conservation status assessment

by N. J. Collar & Rudyanto

SUMMARY

The enterprise of naming all life-forms on earth reached its zenith in the years 1850–1950, but it is often forgotten that our knowledge of the *distributions* of species stems primarily from the same museum endeavour. However, various good reasons dictate that not all material deposited in museums is documented in the public domain, leaving the conservationist with a rich body of essentially new (if commonly predictable) information for use in fixing the ranges (and indeed ecologies) of threatened species. By its use of museum material, BirdLife International's Red Data Book programme has found numerous significant range extensions (whose effect—predictably, given that more localities indicate a wider extent of occurrence and stronger population—is generally to diminish the concern with which the species in question are regarded). Drawing on 60 museums, *Threatened birds of the Americas* used unpublished museum range and ecological data in 232 (77%) and 138 (46%) species accounts respectively. Drawing on 30 museums, *Threatened birds of the Philippines* identified a total of 830 localities, 228 (27%) of which were based *solely* on museum evidence. Museums also hold contentious specimens that require re-evaluation, but there is disconcerting evidence of the decline of the specimen-based taxonomy which helps to bind conservation and science together.

Naming and placing

All modern endeavours concerning biological diversity—its manifestations, patterns, measurement and conservation—rest almost entirely on the extraordinary programme of classification that natural history museums in Europe and the U.S.A. accomplished mainly in the period 1850–1950. This great century of accumulation, evaluation and synthesis of biological material was facilitated and fuelled by European capitalist-imperialist expansion (victory in the Second Opium War, suppression of the Indian Mutiny, and so on) and by the socially and intellectually convulsive insights of Darwin & Wallace (1858). It was effectively finished off by the colonial dismantlings in the aftermath of the Second World War (70 independent sovereign states in 1945; over 170 in 1975) and by the decisive (if debatable) observation of Mayr (1946) that 'the period of new discoveries is practically at an end'.

In that period, the vast majority of all known vertebrate (and perhaps invertebrate and plant) reference material was assembled—often (it is worth remembering) at the great personal risk and expense of the collectors themselves (see, e.g., Stewart 1984, Mearns & Mearns 1998:40-42). Taxonomy was *the* biological science of the late nineteenth century, and its practitioners worked with single-minded energy on the identification and attribution of this flood of material, issuing catalogues and accounts of collections with a regularity and thoroughness that defies modern comparison. The British Museum's million or so bird specimens were almost all acquired during this period, thus at an average of 10,000 a year, or some 40 every working day (by 1990 the intake was under 50 *per year*: Knox & Walters 1992), and in the years 1874–1898, when the hundred-year period in question was less than half run, the trustees issued a catalogue of its avian material, running to an encyclopaedic 27 volumes with an accumulated length of very approximately 16,000 pages. This work was descriptive and synthetic: everything was assigned an identity by matching it to published evidence, so that huge synonymies were accumulated as taxonomists sought to determine the status of specimens and the priority of names associated with them. A major element in this process was the provenance of the material, which allowed museum workers to anticipate whether they were dealing with species already documented elsewhere. As a consequence, from this monumental labour a coherent pattern of the *distributions* of species began, slowly but steadily, to emerge.

It is remarkable how slight public appreciation has been and remains of this crucial role played by museums in defining both species *and* ranges. Our entire understanding of faunas and floras around the world stems from the great systematics enterprise, begun effectively with Linnaeus two and a half centuries ago and now—at a point when it might be thought no longer achievable or even necessary—formulated outright (as for example 'Systematics Agenda 2000': *Biodiversity and Conservation* 4 no. 5 [1995]; and the 'All Species Inventory': Lawler 2001, Gewin 2002), of identifying and classifying every one of the species alive today on earth; yet the debt, owed very largely to the great nineteenth-century museums of Europe and North America, continues to go almost entirely unacknowledged.

Undocumented material: new voyages of discovery

For various reasons, only a moderate proportion of the information attaching to holdings in a natural history museum is likely ever to be published. There is, to begin with, the time-lag between acquisition and classification, given the predictable difficulties in identifying parts of the material. (It is worth making the point that museums create their own in-house expertise: taxonomy is a skill acquired by its *practice*, and the speed and accuracy of workers at any given point is almost certainly correlated with the length of their employment.) Second, in any working museum the appropriate staff must inevitably be otherwise engaged, so that sometimes even commissioned collections will be set aside for the sake of other priorities and commitments. Third, when material is bought or bequeathed or delivered in bulk—i.e. when acquisitions occur randomly (see, e.g., Kitchener & McGowan 2003, this issue)—the human resources needed to undertake a full review of incoming stock are unlikely to be available for years or even decades (if at all). Fourth, it is not in any case the remit of museums publicly to itemise their holdings (despite the precedent of certain institutions in the nineteenth century): reasons of economy combine with the immediate interests of science in restricting publications to the more significant additions and the insights they bring. Fifth, the financial fortunes of museums vary over time like all other institutions, public or private, and inevitably many have lost the power to curate or publish on their holdings.

As a consequence of all this, a great deal of information associated with museum material never enters the public domain, and represents a resource awaiting any number of future uses. One might expect that, even if the information itself remains undisclosed to the public, the public would at least be aware that such information exists; yet this is not (or at least not always) so, nor is it even the case that directly interested parties, such as natural history students and conservationists, who stand to gain most from the resource, recognise the fact; indeed, even curatorial staff themselves sometimes seem oblivious to the importance of this aspect of the material in their care. The fact remains, however, that so much unpublished information resides on the labels of specimens in most major and many minor natural history museums around the world that a visit to any one of them represents something of a voyage of discovery in miniature: even today, the opening of a cabinet door can bring a researcher face to face with startling new evidence, intriguing new puzzles, and even—on the rarest occasions—hitherto unrecognised new species.

This circumstance has been particularly important for the assessment of bird species conservation status at the global level. The quality of such assessments depends directly on the completeness of the information assembled (Collar 1996). Naturally the majority of information comes from published sources, and much of it is supplemented and updated by the personal testimony of field experts. However, the material stored in museums, although sometimes ancient and ostensibly therefore irrelevant, represents another data source which should not be neglected or underestimated. Since the early 1980s museums have played an integral role in the data-generating processes of BirdLife's Red Data Book programme and, as the following examples indicate, have contributed in large measure to a better understanding of the true ranges of many species. This in turn has affected perceptions over their conservation needs and options, the general effect—by increasing the number of locations for species, and therefore the sense of their numerical status—being to *reduce* the sense of alarm over status that the thitherto less complete published data have inevitably tended to create.

Three policies followed in the Red Data Book programme are relevant here. The first is the obligation to cite every source from which an item of information is derived. The second is the decision *not* to cite information from unpublished sources if it already exists in published sources. The third is the requirement that, wherever possible, a locality record for a species should also have a month and year attached. Therefore any reference in a Red Data Book species account to a museum-derived item of information indicates something that cannot be (or at least has not been) found in the literature; this may be a record representing an entirely new locality, but it may also simply be an extra datum that adds to published information (for example, in museum catalogues and accounts of particular collections, localities were sometimes given without dates; these can often be supplied by direct reference to the specimen evidence).

With this clarification, it is possible to understand how munificent a contribution museum data have made to the process of global conservation status assessment in birds. *Threatened birds of the Americas* (Collar *et al.* 1992) documents 302 species in full, with every reasonable attempt having been made to assemble as much information as possible relevant to their conservation (as token of which the bibliography itemises some 2,600 references and occupies 80 pages of text, while some 550 correspondents are acknowledged for information provided through personal communications). In spite of this effort, no fewer than 232 (77%) of these accounts carry previously unpublished range data from museums; and 138 (46%) carry previously unpublished ecological data from museums. No fewer than 60 museums are listed as sources of information in the introduction to the book.

While of course it cannot be claimed that all these items were of particular significance—some, for example, merely established an entirely predictable locality, food or clutch size—the figures clearly suggest that increased substance and authority was brought to the book through the addition of museum data. Some individual items of information were, however, particularly important, and here we select some of these as well as others from the companion volumes *Threatened birds of Africa and related islands* (Collar & Stuart 1985) and *Threatened birds of the Philippines* (Collar *et al.* 1999).

International range extensions

The BirdLife Red Data Book programme has uncovered and published first species records for at least five countries, namely: Dwarf Tinamou *Taoniscus nanus* in Argentina (two specimens in BMNH), Chestnut-throated Spinetail *Synallaxis cherriei* in Colombia (two specimens in FMNH), White-necked Picathartes *Picathartes gymnocephalus* in Guinea (five specimens in ZFMK), Grey-necked Picathartes *P. oreas* in Equatorial Guinea (specimen in EBD; information passed to and first published by Ash 1991) and Nimba Flycatcher *Melaenornis annamarulae* in Ivory Coast (specimen in MNHM). Collar *et al.* (1992) also provided the first unambiguous records of Yellow Cardinal *Gubernatrix cristata* from Paraguay (specimens in BMNH, also MCZ). Clearly one effect of these discoveries is to extend the responsibility for the conservation of the species in question to new countries, although this is not to suggest that it in any way diminishes the responsibility of those countries to which the species were previously believed confined.

State or province range extensions

Significant within-country range extensions (involving new political subunits or mountain ranges) based solely on museum material have been documented for several countries in the Caribbean and Central and South America, for example: records of Rusty-flanked Crake *Laterallus levraudi* in Carabobo and Miranda states, Venezuela (12 specimens in AMNH, ANSP, COP, USNM); Chestnut-bellied Hummingbird *Amazilia castaneiventris* in Santander, Colombia (nine specimens in DMNH, LACM, WFVZ); Black Inca *Coeligena prunellei* in the Central Andes of Colombia (specimen in MHNUC); Blue-headed Quail Dove *Starnoenas cyanocephalus* in Guantánamo, Cuba (multiple specimens from seven localities in AMNH, BMNH, CM, FMNH, MCZ, USNM); Eared Quetzal *Euptilotis neoxenus* in Nayarit, Zacatecas and Michoacán, Mexico (14 specimens in BMNH, DMNH, MCZ, USNM); Keel-billed Motmot *Electron carinatum* in Tabasco, Mexico (specimen in USNM); Three-toed Jacamar *Jacamaralcyon tridactyla* in Espírito Santo, Brazil (six specimens in MNRJ); Cuban Flicker *Colaptes fernandinae* in Guantánamo, Cuba (multiple specimens—including 39 from around Guantánamo town and bay—from nine localities in MNHM, ROM, USNM); Imperial Woodpecker *Campephilus imperialis* in Nayarit, Mexico (specimen in MLZ); Moustached Woodcreeper *Xiphocolaptes falcirostris* in Goiás and Pernambuco, Brazil (specimens in MNRJ and MZUSP respectively); Multicoloured Tanager *Chlorochrysa nitidissima* in Caldas, Colombia (specimen in USNM); and Turquoise Dacnis *Dacnis hartlaubi* in Quindío, Colombia (specimen in ICN).

Significant proportions of range data

Some threatened species, although relatively unknown in the literature, prove to be surprisingly well represented by museum specimens, and thus our knowledge of their ranges has been substantially enhanced. Perhaps the most striking example is the White-tailed Sabrewing *Campylopterus ensipennis*, established by Collar *et al.* (1992) as known from 23 localities, although only 5–6 of them had until that point been published, the remaining 17–18 being based solely on museum specimens (in AMNH, ANSP, BMNH, CM, COP, FMNH, LACM, USNM, YPM; see Fig. 1). Other notable cases include Nahan's Francolin *Francolinus nahani*, six of whose 11 known sites (in 'Zaïre') were established from museum material (in IRSNB, MNHM, MRAC); Yellow-eared Parrot *Ognorhynchus icterotis*, with 13 'museum' sites out of 23 all told (in AMNH, ANSP, BMNH, FMNH, LACM, MCZ, MECN, USNM, YPM; see Fig. 2); Giant Antpitta *Grallaria gigantea*, with 12 out of 21 (in AMNH, ANSP, BMNH, FMNH, IRSNB, MHNG, MNHN, USNM, WFVZ); Cochabamba Mountain-finch *Poospiza garleppi*, with seven out of 13 (in BMNH, CM, MCZ, NRM, ZMUC); and Saffron-cowled Blackbird *Xanthopsar flavus*, with 31 out of 71 (in AMNH, BMNH, FMNH, MCN, MNHN, MNHNM, MNRJ, MZUSP, UMZC).

Range extensions in Madagascar

In the century before the Second World War the birds of Madagascar were heavily collected by American, Dutch, English, French and German explorers, but even today the island remains inadequately documented ornithologically, nor has the breadth of the existing museum material been fully appreciated or utilised. The publication by Langrand (1985) of a significant but overlooked collection of Malagasy birds in the museum in Grenoble was an important reminder of the possibilities of provincial museums (see Roselaar 2003, this issue). In the early 1980s the most recent book available on the Malagasy avifauna dated back to 1970, and subsequent information on the rarest species and their habitats was largely anecdotal. Plotting

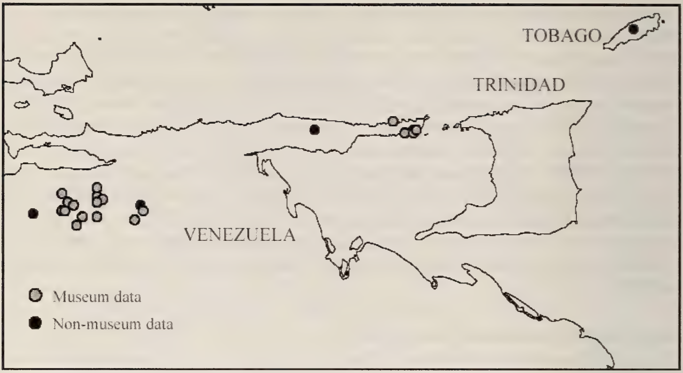

Fig. 1. The range of White-tailed Sabrewing *Campylopterus ensipennis*. Black circles are localities identified from published sources. Grey circles are localities identified from unpublished museum specimens.

the ranges of these birds was crucial to understanding the severity of their plight, and the museum evidence of north-west Europe (no budget then existed for Red Data Book research further from Cambridge, U.K., than Frankfurt-am-Main) proved to be indispensable. From it came proof of (at least former) occurrence of the Madagascar Fish-eagle *Haliaeetus vociferoides* on the north-east coast (specimen in RMNH); Brown Mesite *Mesitornis unicolor* as far north as Antongil Bay (specimens in RMNH), a range extension of 300 km; Scaly Ground-roller *Brachypteracias squamiger* as far south as Andohahela (specimen in SMF), a range extension of 750 km; Pollen's Vanga *Xenopirostris polleni* as far south as 30 km north of Taolanaro (Fort Dauphin) (specimen in MNHN), a range extension of 350 km (information which reduced the threat status of the species from the highest category in which it had been placed by King [1978-1979]); and Madagascar Yellowbrow *Crossleyia xanthophrys* south to the Betsileo region (specimen in BMNH), a range extension of some 250 km.

Range and natural history parameters in the Philippines

Following volumes on threatened birds in Africa and the Americas, the BirdLife Red Data Book programme turned in the mid-1990s to Asia. However, because the Philippines had recently emerged as the world's leading nation for the highest number of highly threatened endemic bird species (Collar *et al.* 1994:24), it was felt appropriate to dedicate a volume exclusively to that country; hence *Threatened birds of the Philippines* (Collar *et al.* 1999).

The Philippines has strong historical and cultural links with the U.S.A., and the museum tradition has been maintained in the country ever since the one-time explorer D. C. Worcester established R. C. McGregor in the Philippine National Museum at the start of the twentieth century (see Dickinson *et al.* 1991:433). The unfortunate destruction in the Second World War of the collections that McGregor and his colleagues had amassed (Sibley 1946) was in large part compensated through the remarkable energies of D. S. Rabor (Kennedy & Miranda 1998), and indeed considerable quantities of his specimens were placed abroad, particularly with U.S. museums. Chicago's Field Museum (FMNH) alone acquired no fewer than 12,500 Rabor specimens (D. E. Willard *in litt.* 2000), and the Delaware Museum of Natural History (DMNH) accumulated material from the expeditions and purchases of J. E. duPont (some involving Rabor) in the lead up to (and for a short time after) the publication of his *Philippine birds* (duPont 1971).

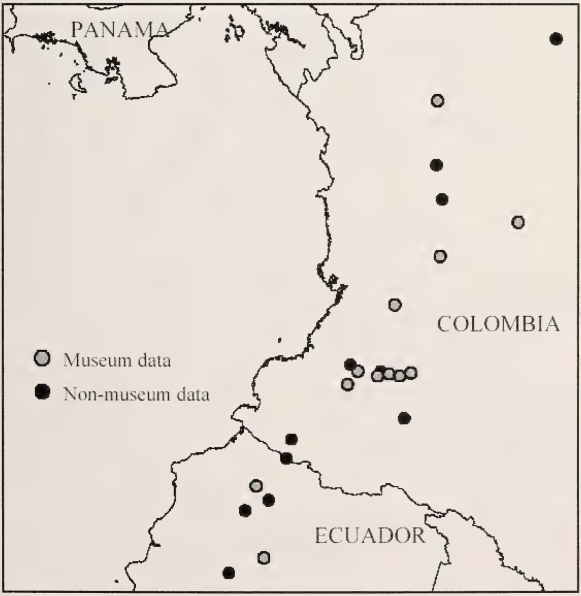

Fig. 2. The range of Yellow-eared Parrot *Ognorhynchus icterotis*. Black circles are localities identified from published sources. Grey circles are localities identified from unpublished museum specimens.

Threatened birds of the Philippines covers 65 species in full, cites around 625 references and acknowledges 104 personal contacts and 30 museums (14 North American, 7 continental European, 6 Philippine, 2 British and 1 Japanese). A total of 830 localities were identified, 228 (27%) of which were based *solely* on museum evidence. We map two species by way of example: Blue-capped Kingfisher *Actenoides hombroni* (22/34, 65%; Fig. 3) and Palawan Hornbill *Anthracoceros marchei* (14/27, 52%; Fig. 4). An even more remarkable circumstance is the Mindanao distribution of Azure-breasted Pitta *Pitta steerii* (it also occurs on Samar, Leyte and Bohol): Collar *et al.* (1994) mistakenly thought the species restricted on Mindanao to the Zamboanga Peninsula, missing two publications from 1993 which reported it from Bislig on the other side of the island, but even so it proves to be in various other parts of the island, with no fewer than 15 of its 18 localities there being derived from previously unpublished museum material.

One notable trend, partly discernible on the maps used, is the way museum material highlights the importance of Samar. Samar is the sister island of Leyte, but

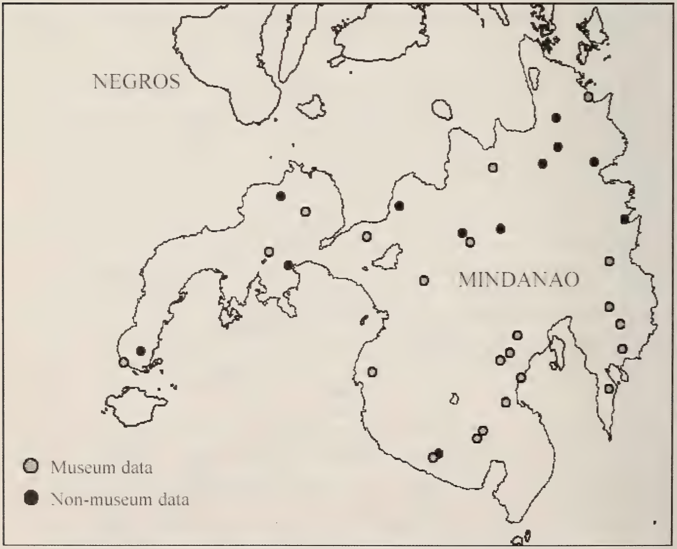

Fig. 3. The range of Blue-capped Kingfisher *Actenoides hombroni*. Black circles are localities identified from published sources. Grey circles are localities identified from unpublished museum specimens.

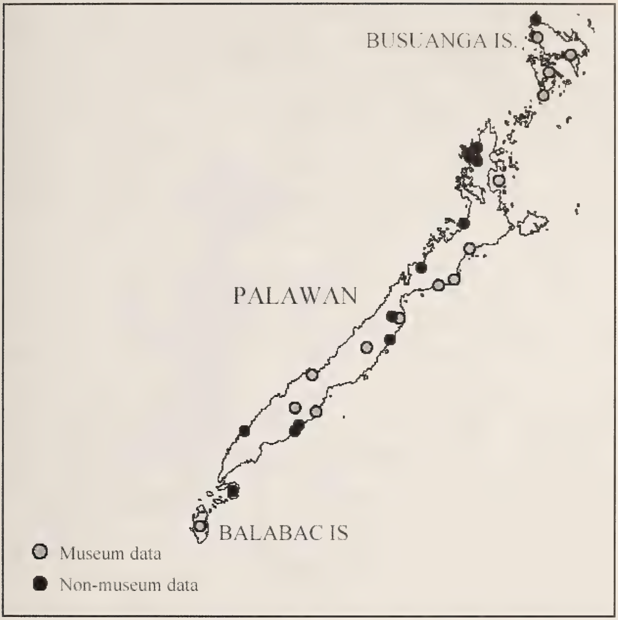

Fig. 4. The range of Palawan Hornbill *Anthracoceros marchei*. Black circles are localities identified from published sources. Grey circles are localities identified from unpublished museum specimens.

whereas Leyte was the subject of a major review by Parkes (1973), Samar has suffered almost complete neglect, with only one paper in the entire twentieth century (Rand & Rabor 1960) devoted even in part to the island's avifauna. Consequently we find that of its 82 localities for threatened species, no fewer than 49 (60%) are derived solely from museum evidence. Without this significant extra body of testimony, Samar would have remained undistinguished and irrelevant to avian and very possibly biodiversity conservation in the Philippines. Moreover, when forest cover is overlaid it transpires that a substantial part of the island is as yet intact; and when logging concessions and protected areas are added, it further emerges that the situation is poised to change rapidly for the worse, and that not a single protected area is in place to mitigate the circumstance (see Fig. 5). When this was disclosed at a priority-setting meeting held after *Threatened birds of the Philippines* went to press, it precipitated a major initiative, with USAID/Global Environment Facility support,

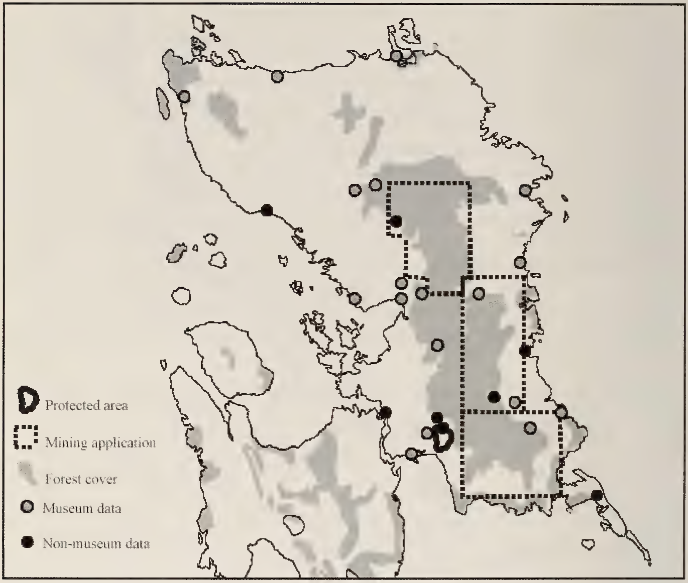

Fig. 5. Point-locality records of threatened birds on Samar, Philippines. Black circles are localities identified from published sources. Grey circles are localities identified from unpublished museum specimens.

to develop a large national park on the island (N. A. D. Mallari verbally 2000). If this duly comes to fruition, it will be in large measure to museum data that future generations will be indebted.

Implications for species status assessment

The fundamental drawback in using museum data is that they are, inevitably, out of date, usually by decades and sometimes by over a century, and therefore there is a strong possibility that the 'new' sites revealed have long become 'old' sites in terms of their avifauna. Habitat destruction has been proceeding so fast in recent decades that we would guess that fewer than 50% of unpublished museum localities still might be sufficiently intact to be available for conservation management. Thus—while always accepting that forest cover overlays tend to be highly schematised and inaccurate—the map of Samar (Fig. 5) shows the elsewhere undocumented collecting sites as all sitting at the edge of known forest, and it is probably the case that most of them have now lost this original habitat.

Even so, it is hardly surprising that the chief effect of the addition of unpublished museum data to information on the distribution of threatened species must be, in general, to reduce the degree of threat under which the species are judged to labour. What basically happens is that the museum data fill out the more expected parts of the map (largely true in Figs. 2–4 and even in Fig.1). After all, really surprising range extensions represented by museum specimens commonly *are* reported in the literature. Inevitably, therefore, it tends to be the rather less interesting material that is allowed to sit undocumented in a cabinet, but even so it would be greatly mistaken to underrate the importance of the corroboration this material furnishes. Again and again we find that species' range maps, as published in otherwise authoritative and revered handbooks and fieldguides, are inaccurate, the product of assumption overlain on assumption. With threatened species, of course, it is particularly important to minimise the use of non-precautionary assumption, and the patient documentation of their ranges, however predictable some of it may be, represents a cardinal obligation in the quest for best judgement.

Equally important is the greater opportunity that a suite of previously unknown sites offers to a conservation manager contemplating the best options for attempting to secure a species's long-term future. This includes the chance to identify key areas based on sympatry of threatened species at given sites. Using the data in Collar *et al.* (1992), Wege & Long (1995) were able to highlight several such areas based exclusively on museum material, for example Parnaguá and Corrente (Piauí, Brazil), from collections made in 1927 and 1958; Santa Ana (La Paz, Bolivia) in 1934; Serranía del Baudó (Chocó, Colombia) in 1912 and 1940; Valle de Yunguilla (Azuay, Ecuador) in 1940 and 1961; Horqueta (Concepción, Paraguay) in 1933 and 1938; Cajabamba (Cayamarca, Peru) in 1894; and San Esteban (Carabobo, Venezuela) in 1875 and 1945.

Unworked material: new insights on distributional and taxonomic status

Ever since point-locality data were deployed in the highly incomplete *Atlas der Verbreitung paläarktischer Vögel* (1960–1989) and the British Museum's two atlases of speciation in African birds (Hall & Moreau 1970, Snow 1978), the fundamental rigour and honesty inherent in this form of range mapping has been self-evident. Sadly, however, it is also extremely labour-intensive and, apart from such rare cases as *Threatened birds of the Philippines* or Paynter's *Nearctic passerine migrants in South America* (1995), point-locality mapping has almost always been used only for single species, sometimes with extensive use of museum data, e.g. Hook-billed Bulbul *Setornis criniger* and the White-throated Babbler *Malacopteron albogulare* (Sheldon 1987), Blue-cheeked Amazon *Amazona dufresniana* (Wege & Collar 1991), Bornean Bristlehead *Pityriasis gymnocephalus* (Witt & Sheldon 1994) and Bearded Tachuri *Polystictus pectoralis* (Collar & Wege 1995). Nevertheless, some of these single-species exercises have a particular value in illustrating the ways in which museum material can transform the received wisdom represented by maps based on less rigorous sources. The following examples relate to elevation, range and date, respectively.

GURNEY'S PITTA ***Pitta gurneyi*** In early 1986 the only hard evidence for the survival of Gurney's Pitta was a live captive bird in Bangkok; even so, the species could then have been declared extinct under CITES criteria, as the last published sighting in the wild had been 50 years previously in 1936, when four birds were collected for Meyer de Schauensee (1946). Curiously, however, a major review of rare birds in Thailand had mapped it as present throughout the forests of the peninsula (Bain & Humphrey 1982), strongly suggesting that alarm for the species was premature. By contrast, the tracing of over 100 specimens of the species and the mapping of every published and unpublished locality (Collar *et al.* 1986) allowed the opposite conclusion to be drawn. It emerged that all sites except one (Meyer de Schauensee's!—apparently owing to deliberate mislabelling by his collectors, intending to suggest that they had ascended a mountain when they had not: Rasmussen & Prŷs-Jones 2003, this issue) were in the *level lowlands*. Accordingly the emphasis of the search for the species was shifted and, with the help of a trade tip-off, the species was rediscovered in June 1986, just in time to initiate conservation measures at what was then the only viable remaining site in Thailand and what is now the only one known in the world (Round & Treesucon 1986, Gretton *et al.* 1993). It was a cause of considerable dissatisfaction that Bain & Humphrey's 1982 map somehow managed to be republished unaltered, in greatly enhanced format (Humphrey & Bain 1991), five years after the truth about Gurney's Pitta was set forth in the public domain.

PLAIN-POUCHED HORNBILL ***Aceros subruficollis*** Both 'editions' of *Birds to watch*, the abbreviated Red Data Book which updates the world list of threatened birds, included Plain-pouched Hornbill, and both credited Kemp (1988) for determining the characters that separate it from Wreathed Hornbill *A. undulatus* (Collar & Andrew 1988, Collar *et al.* 1994). Even so, Kemp (1995) was evidently unable to apply his insights to the breadth of museum material available, since he mapped the species as occurring throughout Myanmar and into north-east India, and shaded in Peninsular Malaysia and Sumatra as possible parts of the range. Only with the detailed inspection and analysis of museum specimens by Rasmussen (2000) has a clarification of the range of the species been achieved, and on this basis it proves to be almost as limited as the original range of Gurney's Pitta, extending from the Thailand–Malaysia border north to Toungoo in south-central Myanmar. The consequences of this important insight are too obvious to state.

VEERY ***Catharus fuscescens*** Work driven by J. V. Remsen, attaching times of year to point-locality records of migrant birds in South America, has begun to revolutionise our perceptions of their annual spatio-temporal patterns (see, e.g., Remsen & Parker 1990, Marantz & Remsen 1991). A striking example involves the Veery, which has been mapped in several publications in the past—including the excellent Paynter (1995)—as occupying a significant segment of northern South America during the boreal winter period. These maps are not 'wrong'; but they are inevitably construed as implying an undifferentiated spread of the population through the areas mapped for the duration of its residency there. By contrast, mostly using museum label data, Remsen (2001) has demonstrated that the Veery undertakes a long loop movement through South America involving a mid-winter pause in a circumscribed area of Brazil in or near the basin of the Rio Xingú. It turns out therefore that the Veery has a much smaller winter range than a simple map would have us believe, because each general staging area in its protracted non-breeding circuit is far smaller than the total area it visits. The loss of any one area, considered as a proportion of the whole, would not result merely in the loss of an equivalent proportion of the bird's population; rather, it might result in the loss of its *entire* population.

The evaluation of problematic specimens

Specimens that defy classification generally qualify as 'undocumented material'. In some cases the matter may be genuinely intractable; in others it may be more one of the experience and ability of the taxonomists. Olson (1986) observed that unique specimens tend to be regarded as 'freaks, hybrids, or... subspecies' and thus 'overlooked and ignored'. It requires considerable time and dedication to investigate such material and attempt to resolve the problems, simply because the returns on such endeavours may be so small. Nevertheless it clearly matters to conservation whether one or a small series of apparently anomalous specimens represents a species or not.

Collar & Stuart (1985) treated at least two taxa known from single specimens over which serious taxonomic doubts have been raised, namely White-chested Tinkerbird *Pogoniulus makawai* and Red-tailed Newtonia *Newtonia fanovanae*. Collar *et al*. (1992) did the same with Magdalena Tinamou *Crypturellus saltuarius*, Coppery Thorntail *Popelairia letitiae*, Táchira Emerald *Amazilia distans*, White-masked Antbird *Pithys castanea*, Cone-billed Tanager *Conothraupis mesoleuca*, Cherry-throated Tanager *Nemosia rourei* and Hooded Seedeater *Sporophila melanops*. Four of these, Coppery Thorntail (Graves 1999), White-masked Antbird (LSUMZ–MHNJP project rediscovery in 2002: D. F. Lane *in litt.*), Red-tailed Newtonia (Goodman & Schulenberg 1991) and Cherry-throated Tanager (Pacheco 1998), have proved to be genuine, while one, Táchira Emerald, has been judged invalid (Weller & Schuchmann 1997, Graves 1998), and another, White-chested Tinkerbird, has been quietly dropped as 'generally considered no more than [an] aberrant individual' of Yellow-rumped Tinkerbird *Pogoniulus bilineatus* (Short & Horne 2002), although G. R. Graves—whose elucidations of taxa known by few or single specimens (e.g. Graves 1992, 1996, 1998, 1999) have been particularly helpful, not least for the perplexed conservationist—has commented informally (verbally 1999) that, following a preliminary (two-hour) inspection of the type, the White-chested Tinkerbird seems likely to prove a good species.

An interesting case—and one which actually conflicts with Olson's thesis, since he regretted the reluctance of ornithologists 'to accept unique specimens as representing valid species'—is the 'Rufous-tailed Parrot' *Tanygnathus heterurus*. Forshaw (1989; previous editions in 1973, 1978) has always treated this under an independent heading, thus giving it at least the illusion of species status (reinforced by a most attractive illustration), despite the fact that his examination of the type suggested that 'it is probably an aberrant specimen of *T. sumatranus*'. Inskipp *et al.* (1988) revealed that over 500 true Blue-backed Parrots *T. sumatranus* (protected under Indonesian law) were traded in the period 1981–1985 under the name *T. heterurus* (unprotected under Indonesian law). They observed that 'it is imperative that the true nature of this taxon is resolved as soon as possible', not least because of the cover it appears to provide for illegal trade in another species. Despite this plea, we know of no recent interest in examining the type specimen afresh.

There are many such taxa whose type and only specimens await evaluation. A helpful feature of the old AMNH world checklist (Morony *et al.* 1975) was its asterisking of species of uncertain status, usually owing to a paucity of material. However, this practice only extended to those taxa which had somehow been given the benefit of the doubt; excluded were taxa which in some cases may simply have received a single negative assessment and thus fallen from sight, amongst them, for example, Spotted Green Pigeon *Caloenas maculata* (Anon. 1898, Peters 1937, Gibbs *et al.* 2001). A list of persistently dubious taxa, whether on or off world lists, is highly desirable as a working document for future researchers; however, the business simply of discovering the discarded yet inadequately evaluated taxa is likely to be problematic, and may only be achievable by a concerted pooling of information by collection managers, who are most likely to know of the oddities in their care. We encourage them to make a start; and it should go without saying that we regard the maintenance of specimen-based taxonomy and systematics as vital to the elucidation of the problems these specimens represent and indeed to the needs of conservationists in general over the coming decades.

Hopes and fears

We call this paper 'the archive and the ark'; we might just as easily have called it 'the anchor and the ark', because natural history museums are to conservation, and indeed to all biological science, the great link to the natural world, a key point of reference, and a mechanism for locking the management of natural resources into the hard substrate of science. These few examples help demonstrate the value of museum collections in one small but significant aspect of conservation work, relating to the documentation and management of threatened species—for a catalogue of other conservation uses see especially Remsen (1995)—and this paper has been written as an expression of gratitude to the many institutions which, over some 20

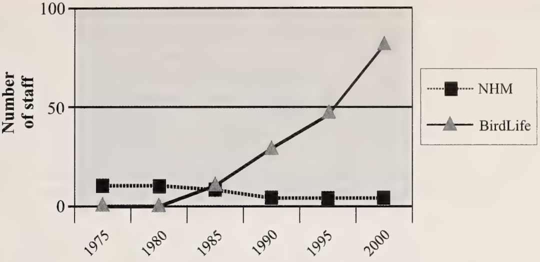

Fig. 6. Staff level changes in two institutions over the same period, 1975–2000: continuous line = BirdLife International Secretariat (including regional offices) executive staff (source: NJC); dashed line = Natural History Museum research and curatorial staff (source: F. E. Warr *in litt.* 2002), but note that the stabilised level from 1990 onwards represents the retention of curatorial staff only, with all research capability removed (see text).

years, have unfailingly made their material available for consultation and use by conservationists from BirdLife International.

It is also written as a gesture of support at a time when natural history museums are, in general, finding it increasingly hard to convince governments and institutions to provide for their vital work. It is as if their political masters have interpreted the close of the great era of exploration and discovery as an indication that there is no more work to do. It is true that a new era of work in natural history has begun—that of conserving as much as possible of the habitats that yielded up all those museum specimens in the previous hundred years or so—but this is not of course to say that such work should *replace* the work of museums. In the period 1975–2000, staffing levels within ICBP/BirdLife International, the world's leading bird conservation organisation, rose from one to almost 90 (9,000%). In the same period, research capacity at the Subdepartment of Ornithology at the Natural History Museum, Tring, where the largest single collection of avian museum material on earth is housed, was reduced by 90% (Collar 1997), with no full-time taxonomist or systematist being employed since 1988 (R. P. Prŷs-Jones verbally 1999; see Fig. 6). It hardly needs to be said that this circumstance is unpropitious. 'Without taxonomy to give shape to the bricks and systematists to tell us how to put them together,' wrote May (1990), 'the house of biological science is a meaningless jumble'. Conservationists are themselves dwellers in the house of biological science, and are likely to be the greatest losers in this scenario. One might go on to say that without taxonomy and systematists to keep the house of biological science orderly and functioning, museums become mausoleums and nature becomes a garden in which conservationists cannot tell weeds from wonders (and in which 'biological diversity' becomes the only, but now meaningless, binomen they can claim to be helping).

Curiously enough, however, some of the most immediate threats to museum specimen collections are from seemingly competitive internal pressures. Molecular studies have become so fashionable in the past two decades, and are apparently so much less expensive and so much more efficacious than more traditional museum science, that they have begun to marginalise specimen collections in the eyes both of space-stressed administrators pondering their budgets and of result-oriented academics planning their immortality. There is no short-term solution to this, but it is of vital importance that biochemical work complements and does not simply replace specimen-based analysis. Most of all, museums need to prove their continuing relevance by being *used*, and one measure to revive their fortunes in the face of official indifference or even hostility might be the re-importation of formal taxonomic studies into university curricula, so that biological research students will possess greater interest and confidence in designing all or part of their projects around the use of museum material.

This will, of course, depend on their being able to get into the institutions in question, which may not in the future be as simple a proposition as it once was. The new recognition that the biochemical properties of species can quickly become the legal properties of businesses has produced a sharp interest amongst parties to the Convention on Biological Diversity in asserting national rights of ownership over specimen material, and a tranche of impending prohibitions on researchers appears to be in the making. 'If implemented as proposed', Grajal (1999) has observed, 'most of the access laws will make biodiversity access permits more difficult for scientists to obtain than for mining concessions, tougher on museums than on hydropower development, and more cumbersome for herbaria than for logging companies'. Indeed, in our work towards the completion of *Threatened birds of Asia*, we were informed (by J. Hon *in litt.* 1999) that to gain access to the Kuching Museum in Sarawak foreign researchers must now obtain (1) a 'Permit to Access, Collect & Research on Biological Resources in Sarawak' from the Sarawak Biodiversity Centre, which entails completing a 20-page form and allowing a three-month processing period, and (2) permits of entry from both the Economic Unit and the State Planning Unit in Kuala Lumpur, which base their decisions in part on the issuance of the Sarawak research permit but which are reported to include other, undisclosed considerations in their decisions.

These new impediments to 'biodiversity prospecting' are understandable, but it will be heavily ironic if they also obstruct the real conservation of the resources in question. A dialogue is urgently needed between users of museums and the institutions that regulate such use in order to reach a fair accommodation of interests. In the same vein, recent requests made by some conservation organisations for full-scale museum 'data dumps', as a quick means of achieving an outward degree of authority in priority-setting exercises, have been greeted with scepticism or worse in some institutions, and they evidently risk causing a general backlash for inadequately acknowledging the professionalism, commitment and sheer expense that underpin the major specimen collections of the world today. Again, if this only serves to produce greater restrictions on access, the irony will be as withering as the effect.

Acknowledgements

Museum initials used in this paper are: AMNH, American Museum of Natural History; ANSP, Academy of Natural Sciences of Philadelphia; BMNH, The Natural History Museum, U.K.; CM, Carnegie Museum of Natural History, Pittsburgh; COP, Colección Ornitológica Phelps, Caracas; DMNH, Delaware Museum of Natural History, Greenville; EBD, Estación Biológica de Doñana, Seville; FMNH, Field Museum of Natural History, Chicago; ICN, Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá; IRSNB, Institut Royal des Sciences Naturelles, Brussels; LACM, Los Angeles County Museum of Natural History; LSUMZ, Louisiana State University Museum of Zoology, Baton Rouge; MCN, Museu de Ciências Naturais, Rio Grande do Sul; MCZ, Museum of Comparative Zoology, Harvard; MECN, Museo Ecuatoriano de Ciencias Naturales, Quito; MHNG, Muséum d'Histoire Naturelle de Génève; MHNJP, Museo de Historia Natural 'Javier Prado', Lima; MHNUC, Museo de Historia Natural, Universidad de Cauca, Popayán; MLZ, Moore Laboratory of Zoology, Occidental College, Los Angeles; MNHN, Muséum National d'Histoire Naturelle, Paris; MNHNM, Museo Nacional de Historia Natural, Montevideo; MNRJ, Museu Nacional de Rio de Janeiro; MRAC, Musée Royale de l'Afrique Centrale, Tervuren, Belgium; MZUSP, Museu de Zoologia, Universidade de São Paulo; NRM, Naturhistoriska Riksmuseet, Stockholm; RMNH, Rijksmuseum voor Natuurlijke Historie (now Naturalis), Leiden, Netherlands; ROM, Royal Ontario Museum, Toronto; SMF, Senckenbergmuseum, Frankfurt; UMZC, University Museum of Zoology, Cambridge, U.K.; USNM, United States National Museum, Washington DC; WFVZ, Western Foundation of Vertebrate Zoology, Los Angeles; YPM, Peabody Museum, Yale, New Haven; ZFMK, Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn; ZMUC, Zoological Museum of the University of Copenhagen.

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The use of sounds in avian systematics and the importance of bird sound archives

by Per Alström & Richard Ranft

SUMMARY

The steady increase in the global total of bird species is in part due to the discovery of distinct vocalisations which reveal hitherto unrecognised information, either the presence of entirely new species or the level of differentiation in taxa previously treated as conspecific. There are many examples of both types of discovery (and some where taxa previously given species status prove conspecific). The importance of vocal analysis in establishing the relationships between taxa is also demonstrated by numerous examples. Avian sound archives are clearly crucial to the advancement of such studies, but many more recordings are needed, their quality must be high, the circumstances of recordings need to be documented, the identity of vocalising birds needs to be firm, and a fuller system of cooperation between sound archives is required.

Introduction

The number of bird species in the world was estimated to be *c.*8,600 by Mayr (1946), *c.*9,000 by Bock & Farrand (1980), and *c.*9,700 by Sibley & Monroe (1990). This increase widely exceeds the number of newly described species in that time period. Part of this increase can be attributed to the growing knowledge of bird vocalisations in combination with the current trend to recognise allopatric taxa with distinctive songs as species rather than as subspecies (Sibley & Monroe 1990, Parker 1991, Price 1996, Peterson 1998).

Although sounds have mainly been of use in the ranking of closely related allopatric taxa, vocalisations have also been used to infer relationships, both within and between genera, and have been crucial in the discovery of several new species. We here review the use of vocalisations and other acoustic signals in systematics; see also Payne (1986) for a thorough review and Morel & Chappuis (1992) for a review of West African taxa. We also discuss the importance of sound archives and suggest how they may be made more useful to future researchers.

The importance of vocalisations in the discovery of new species

Several new species have been discovered because of their distinct vocalisations. Some of these escaped attention because they are highly secretive and difficult to see, and others because they are sibling species which are morphologically similar to other species. Several examples are given here.

A rallid heard in September 1997 on a steep mountain slope in primary forest in the Talaud archipelago, Indonesia, later proved to be an undescribed species, the Talaud Bush Hen *Amaurornis magnirostris* (Lambert 1998).

The existence of two new species of Andean pygmy-owls, Subtropical Pygmy Owl *Glaucidium parkeri* (Robbins & Howell 1995) and Cloud Forest Pygmy Owl *G. nubicola* (Robbins & Stiles 1999), was first indicated from tape-recordings of their voices.

The Cryptic Warbler *Cryptosylvicola randrianosoloi* was first detected in 1992 in eastern Madagascar by its voice (Goodman *et al.* 1996) and it was subsequently found to be common (Morris & Hawkins 1998). Likewise it was its song that first disclosed the presence of the Jocotoco Antpitta *Grallaria ridgelyi* in the Andes of southern Ecuador (Krabbe *et al.* 1999).

The Ancient Antwren *Herpsilochmus gentryi* was discovered by José Alvarez Alonso and Bret Whitney when Whitney identified it as a new species from among Alvarez's unclassified tape-recordings of unseen canopy birds from Peru (Whitney & Alvarez Alonso 1998). They later managed to find it in the field (and to collect two birds), confirming its distinctness.

Four new species of *Scytalopus* tapaculos from South America, Chocó Tapaculo *S. chocoensis*, Chusquea Tapaculo *S. parkeri* (Krabbe & Schulenberg 1997), Diademed Tapaculo *S. schulenbergi* (Whitney 1994) and Tall-grass Wetland Tapaculo *Scytalopus iraiensis* (Bornschein *et al.* 1998), were discovered because their songs differed from other known species.

The observation that there were 'two markedly different vocal types', and pronounced differences in display, in what was originally believed to be Suiriri Flycatcher *Suiriri suiriri* led to the discovery of the Chapada Flycatcher *Suiriri islerorum* (Zimmer *et al.* 2001).

The song of the Nepal Wren Babbler *Pnoepyga immaculata* (Martens & Eck 1991) was long thought to be a variant of the song of Scaly-breasted Wren Babbler *P. albiventer*. It was later realised that the individuals with this kind of song also differed morphologically from Scaly-breasted Wren Babbler, and the existence of a previously unknown species was thus revealed.

Three previously unknown species of warblers were discovered in China during the 1990s as a result of their vocalisations. Emei Leaf Warbler *Phylloscopus emeiensis*, restricted to a small area in central China, was first noted because its song and call differed markedly from two other sympatric, similar-looking species, Blyth's Leaf Warbler *P. reguloides* and White-tailed Leaf Warbler *P. davisoni* (Alström & Olsson 1995). Vocalisations were also of paramount importance in the discovery of two new species of *Seicercus* warblers, *S. soror* and *S. omeiensis*, and in the elucidation of a group of sibling species (Alström & Olsson 1999, 2000, Martens *et al.* 1999; see below). Other new warblers have been found because of their distinct vocalisations, e.g. Dorst's Cisticola *Cisticola dorsti* (Chappuis & Erard 1991) and River Prinia *Prinia fluviatilis* (Chappuis 1974), both from West to Central Africa.

The Taiwan Bush Warbler *Bradypterus alishanensis* was previously treated as the subspecies *melanorhynchus* of Russet Bush Warbler *B. mandelli* (=*seebohmi*), but was described as a new species (Rasmussen *et al.* 2000a) when it was realised that its song differed markedly from other populations of Russet Bush-warbler and that no name was available for this population.

No fewer than three indigobirds, Jos Plateau *Vidua maryae*, Goldbreast *V. raricola* and Barka *V. larvaticola*, were discovered mainly because of their songs (Payne 1982, 1998, Payne & Payne 1994). However, the discrimination of the first of these species led to the even more remarkable discovery of the Rock Firefinch *Lagonosticta sanguinodorsalis* (Payne 1998). Indigobirds are species-specific brood parasites that mimic the songs of their host species, mainly firefinches *Lagonosticta* spp. (e.g. Payne 1968, 1973a, 1973b, 1982, Payne & Payne 1994), so when it was realised that the song of the Jos Plateau Indigobird differed from the songs of all other indigobirds, it was predicted that there must be an unknown firefinch song model in the area.

At least two new species of corvid, Sinaloa Crow *Corvus sinaloae* from western Mexico (Davis 1958) and Little Raven *C. mellori* from southern Australia (Rowley 1967a,b), were discovered because of differences in vocalisations from other species, in the second case a sympatric species (Australian Raven *C. coronoides*).

The importance of vocalisations in the assessment of taxonomic rank

There are many cases, in a wide range of genera, where allopatric taxa have been 'upgraded' from the rank of subspecies to species, or even from colour morph to species, because of differences in their acoustic signals. The converse is less common. Some examples are presented here.

The North American Western Grebe *Aechmophorus occidentalis* and Clark's Grebe *A. clarkii* were previously considered to be colour morphs of the same species (Western Grebe *A. occidentalis*). However, Nuechterlein (1981) showed that the 'advertising call' used in mate attraction differs significantly between the two and that, in an area of sympatry, each 'morph' responded almost exclusively to its own call. This confirmed the studies of Storer (1965) and Ratti (1979), which had shown strong assortative mating in these 'morphs'.

In many seabirds, especially those that breed in burrows and only visit their breeding islands at night, females probably identify conspecific males by their vocalisations, at least at long range (James & Robertson 1986, Bretagnolle 1990, 1995, Bretagnolle *et al.* 1990, Bretagnolle & Robinson 1991). Studies of sounds have sometimes revealed differences between populations that were considered conspecific, and have been used in conjunction with other evidence to show that these taxa are better considered separate species. The Antarctic Prion *Pachyptila desolata*, Salvin's Prion *P. salvini*, Broad-billed Prion *P. vittata*, Slender-billed Prion *P. belcheri* and Fairy Prion *P. turtur* have been treated differently by different authors on the basis of morphological data. Bretagnolle *et al.* (1990) studied these taxa on their breeding islands, where two to four occurred in sympatry. They showed that their voices (as well as morphology, phenology of breeding and diet) differed consistently, especially in sympatric taxa, and they therefore considered all to be separate species.

Bretagnolle (1995) analysed the vocalisations of Soft-plumaged Petrel *Pterodroma mollis* from several different localities. Based on this (in conjunction with morphological characters), he concluded that the Soft-plumaged Petrel should be split into two species, one in the northern hemisphere, *P. feae*, and one in the southern hemisphere, *P. mollis*. (It should be mentioned that others, following the lead of Bourne [1983], believe that the North Atlantic taxa *feae* and *madeira* should be treated as separate species based on morphological differences, although Bretagnolle [1995] remarked that their calls were similar and overlapped.)

The Herald Petrel *Pterodroma heraldica* was formerly believed to have a dark-bellied and a pale-bellied colour morph. However, Brooke & Rowe (1996) noted consistent differences in the vocalisations of pale and dark birds (especially in the rate of delivery of the calls in a series). These differences, in combination with evidence of assortative mating and lack of gene flow, led them to propose that the two morphs are in fact separate species, Herald Petrel *P. heraldica* and Henderson Petrel *P. atrata*.

The 22 currently recognised species of megapode Megapodiidae differ little in plumage, but markedly in bare-part colours and proportions (Roselaar 1994, Jones *et al.* 1995). Although their vocalisations are imperfectly known, there are 'minor differences between the races and sometimes marked ones between species', supporting the proposed classification (R. W. R. J. Dekker in Roselaar 1994).

Even in groups such as bustards Otididae, which are not very vocal, voice has proved useful in taxonomic assessments. It is now widely accepted that the Crested Bustard *Eupodotis ruficrista* involves three allopatric species owing to differences in vocalisations and morphology (Chappuis *et al.* 1979, Morel & Chappuis 1992, Payne *et al.* 1997); and it has been suggested by Gaucher *et al.* (1996) that the Houbara Bustard *Chlamydotis undulata* is better treated as two allospecies, *C. undulata* and *C. macqueenii*, owing to differences in 'display call' and courtship display (supported by morphological and genetic differences).

Acoustic signals have been used comparatively rarely in wader taxonomy, despite the fact that most waders have distinct sound displays. The Amami Woodcock *Scolopax mira* is an exception. It was once treated as a subspecies of the Eurasian Woodcock *S. rusticola*, but Brazil & Ikenaga (1987) pointed out differences in (among other things) vocalisations and the apparent lack of a display flight.

Thönen (1969), Olsson (1987) and Miller (1996) remarked that the 'drumming' made by the tail-feathers during flight display differed between European (nominate) and North American (subspecies *delicata*) populations of Common Snipe *Gallinago gallinago*. Based on this (in combination with morphological differences), they suggested that these should be considered separate species.

American Golden Plover *Pluvialis dominica* and Pacific Golden Plover *P. fulva* were formerly treated as conspecific (under the name American Golden Plover *P. dominica*). Connors *et al.* (1993) studied these taxa in an area of sympatric breeding in western Alaska and showed that there were consistent differences in vocalisations ('song', alarm calls and other calls) and in habitat choice, and that mating was assortative. Byrkjedal & Thompson (1998) came to the same conclusions. These results supported the proposition by Connors (1983), based on a study of specimens, that these taxa are separate species.

Miller (1996) noted differences in five variables in the display vocalisations of Common Ringed *Charadrius hiaticula* and Semipalmated *C. semipalmatus* Plovers, but only very slight intra-taxon differences over large areas. These findings lent support to the widely accepted notion that these taxa are better treated as separate species.

Song characteristics have been used to re-estimate species limits in several cuckoos: Square-tailed Drongo Cuckoo *Surniculus dicruroides*, Round-tailed Drongo Cuckoo *S. lugubris*, Moluccan Drongo Cuckoo *S. musschenbroeki* and Philippine Drongo Cuckoo *S. velutinus* (Payne 1997, in press); Horsfield's Cuckoo *Cuculus optatus* (*=horsfieldi*) and Oriental Cuckoo *C. saturatus* (Payne 1997, but lumped in Payne [in press] 'because a larger sample of songs shows some overlap, and specimens show overlap also': R. B. Payne *in litt.*); Common Cuckoo *C. canorus* and African Cuckoo *C. gularis* (Payne 1986, Morel & Chappuis1992); Rufous Hawk Cuckoo *Hierococcyx hyperythrus*, Philippine Hawk Cuckoo *H. pectoralis*, Whistling Hawk Cuckoo *H. nisicolor* and Javan Hawk Cuckoo *H. fugax* (Payne 1997, in press, King 2002); and Asian Lesser Cuckoo *C. poliocephalus* and Madagascar Lesser Cuckoo *C. rochii* (Becking 1988, Payne in press).

In owls, voice has often been of major importance in the assessment of taxonomic rank. The classic study by Marshall (1978) on small Asian owls, in which he classified taxa with dissimilar vocalisations as separate species and, conversely, taxa with similar vocalisations as conspecific, led to a multitude of taxonomic rearrangements. For example, he suggested species status for no fewer than seven scops owls (genus *Otus*) that had previously been treated as subspecies. Other studies on the voices of Asian scops owls have been important in resolving taxonomic matters, and have further increased the number of recognised species (Roberts & King 1986, Marshall & King 1988, Becking 1994, Lambert & Rasmussen 1998).

Another example is that all the taxa previously associated with *Otus rutilus* of Madagascar have been shown to differ in voice (and morphology), and have been suggested to be treated as separate species: *O. moheliensis* (Lafontaine & Moulaert 1998), *O. capnodes* (Safford 1993), *O. pauliani* (Herremans *et al.* 1991), *O. [r.] mayottensis* (Lewis 1998), *O. madagascariensis* and *O. rutilus* (Rasmussen *et al.* 2000b). Chappuis (1974–1985) and Morel & Chappuis (1992) suggested that European Scops Owl *O. scops* and African Scops Owl *O. senegalensis* should be considered separate species based on differences in voice.

The Least Pygmy Owl *Glaucidium minutissimum*, which is widely distributed in South America, was formerly treated as a polytypic species. However, Howell & Robbins (1995) analysed vocalisations and in conjunction with morphology and other evidence suggested that it ought to be treated as four separate species.

Vocalisations have been used extensively in taxonomic revisions of nightjars. For example, Jerdon's Nightjar *Caprimulgus atripennis*, Sulawesi Nightjar *C. celebensis* and Philippine Nightjar *C. manillensis* were all split from Large-tailed Nightjar *C. macrurus* because of their distinctive vocalisations (Mees 1985, Ripley & Beehler 1987, Rozendaal 1990). Likewise, Tawny-collared Nightjar *C. salvini*, Yucatan Nightjar *C. badius* and Silky-tailed Nightjar *C. sericocaudatus* have been judged to be specifically different on the basis of differences in voice (Hardy & Straneck 1989). Conversely, Dowsett & Dowsett-Lemaire (1993) pointed out that the songs of Fiery-necked Nightjar *C. pectoralis* and Black-shouldered Nightjar *C. nigriscapularis* were similar, and suggested that these should be treated as conspecific. They also showed that the taxa *ruwenzorii* (Ruwenzori Nightjar), *guttifer* (Usambara Nightjar) and *poliocephalus* (Abyssinian Nightjar), which have at one time or another been considered separate species, are best treated as conspecific, under the name Montane Nightjar *C. poliocephalus*, owing to basically similar vocalisations. (It should, however, be noted that Cleere [1995], also using vocal characters, disagreed with this assessment.)

Voice has been important in the assessment of species status of a taxon that is believed to be extinct in the wild: Grayson's Dove *Zenaida graysoni* from Socorro Island south-west of Baja California (Baptista *et al.* 1983). It was established that the voice (and visual display) of this bird differ significantly from the Mourning Dove *Z. macroura*, with which it has often been considered to be conspecific. It was also noted that it only rarely interbreeds with Mourning Dove in captivity.

Vocalisations have been used to assess the taxonomic rank in other doves. The insular endemic Grenada Dove *Leptotila wellsi* was shown to differ vocally (as well as morphologically) from the closely related continental Grey-fronted Dove *L. rufaxilla* (Blockstein & Hardy 1989). Playback tests were also of importance in this re-evaluation. Chappuis (1974–1985) and Morel & Chappuis (1992) showed that the vocalisations of the morphologically closely similar Eurasian Collared Dove *Streptopelia decaocto* and African Collared Dove *S. roseogrisea* differ markedly, and proposed species status for them.

Pittas Pittidae have loud, relatively simple songs which have been used (in conjunction with especially morphology) to show that the mainly allopatric Fairy Pitta *Pitta nympha*, Blue-winged Pitta *P. moluccensis*, Indian Pitta *P. brachyura* and Mangrove Pitta *P. megarhynchus* are best treated as separate species (Lambert 1996, Lambert & Woodcock 1996).

The Neotropical Tyrannidae include many species that are poorly differentiated morphologically, and vocalisations have often been of great importance in the recognition of species. Lanyon (1978) used vocalisations and playback tests extensively in his monumental revision of the genus *Myiarchus*, because he was 'convinced that the use of vocal characters, in conjunction with more conventional morphological characters, would be the key to any successful attempt to determine specific limits and relationships within the genus'. He proposed several taxonomic rearrangements based on this research.

Willow Flycatcher *Empidonax traillii* and Alder Flycatcher *E. alnorum* were formerly considered conspecific, but Stein (1958, 1963) showed that they differed in vocalisations and other aspects, did not respond to playback of each other's songs and were partly sympatric. Similarly, studies of vocalisations together with morphology and allozymes showed that the Western Flycatcher *E. difficilis* of western North America was in fact two separate, partly sympatric, species: Pacific-slope Flycatcher *E. difficilis* and Cordilleran Flycatcher *E. occidentalis* (Johnson 1980, Johnson 1994).

The species in the South American suboscine genus *Scytalopus* (tapaculos) are extremely similar in plumage and structure, and are very secretive and difficult to observe (e.g. Fjeldså & Krabbe 1990, Ridgely & Tudor 1994). Until recently, their classification was based on comparative studies of museum specimens (Zimmer 1939, Peters 1951). A review by Krabbe & Schulenberg (1997) using vocalisations (in combination with morphology and distribution) led to a virtual 'explosion' of species, from 11 recognised by Zimmer and Peters to no fewer than 37. Three of these, Chocó Tapaculo *S. chocoensis*, Ecuadorian Tapaculo *S. robbinsi* and Chusquea Tapaculo *S. parkeri*, were new to science, and an additional two or three were considered to be undescribed. Several of the species were shown to be sympatric. Krabbe & Schulenberg classified allopatric taxa with unique songs as species, an approach that was supported by DNA data presented by Arctander & Fjeldså (1994).

The use of vocalisations has led to the recognition of many South American Thamnophilidae and Formicariidae as species. For example, Isler *et al.* (1997) suggested that the widely distributed polytypic Slaty Antshrike *Thamnophilus punctatus* is better treated as at least six separate allospecies; Isler *et al.* (1999) argued that Streaked Antwren *Myrmotherula surinamensis* should be treated as four species; and Whitney *et al.* (2000) concluded that the Black-capped Antwren *Herpsilochmus pileatus* complex consists of three species, of which one, Caatinga Antwren *H. sellowi*, was previously undescribed because it had been confused with *pileatus* for almost a century.

The Bengal Bushlark *Mirafra assamica* was previously treated as a polytypic species ranging from India to Sri Lanka and Vietnam. However, Alström (1998) showed that there are pronounced differences in songs, calls and song-flights (as well as morphological differences, and in one case in habitat) between four allopatric taxa. Based on this, he proposed that they be treated as four separate species.

Bicknell's Thrush *Catharus bicknelli* has received much interest lately, because it has been shown to differ from Grey-cheeked Thrush *C. minimus* (with which it was formerly considered conspecific) in a number of aspects, including song (and lack of response to playback to two other subspecies of Grey-cheeked Thrush, *minimus* and *aliciae*) (Ouellet 1993).

Old World warblers are renowned for being morphologically poorly differentiated, although the species usually differ more clearly by their songs. This was noted more than 200 years ago, when White (1789) remarked that 'I have now, past dispute, made out three distinct species of the willow-wrens (*motacillæ trochili*) which *constantly* and *invariably* use distinct notes.' He was referring to Willow Warbler *Phylloscopus trochilus*, Common Chiffchaff *P. collybita* and Wood Warbler *P. sibilatrix*, of which only the first had at that time been named. In fact, in the genus *Phylloscopus* (leaf warblers) in Eurasia excluding the Philippines, Greater Sundas and Wallacea, the number of recognised species went up by 31% in the last decade, and in all except two species, songs were important in the assessment of their taxonomic rank (Irwin *et al.* 2001). Two examples are given below.

Pallas's Warbler *P. proregulus* used to be considered a wide-ranging polytypic species, breeding in Siberia, northern Mongolia and north-east China (nominate *proregulus*); central China and the Himalayas west to central Nepal (subspecies *chloronotus*); and western Himalayas (subspecies *simlaensis*); a fourth taxon, *kansuensis*, from northern central China, was treated as a synonym of either *proregulus* or *chloronotus*. First, Alström & Olsson (1990) proposed that *proregulus* and *chloronotus/simlaensis* should be treated as two separate species based on pronounced differences in vocalisations and lack of response to playback of each other's songs. Subsequently, Alström *et al* (1997) pointed out that *kansuensis* also differed considerably in vocalisations from the others, and did not respond to playback of their songs, and concluded that it ought to be treated as a separate species. Meanwhile, Alström *et al.* (1992) found a species with unique vocalisations that was sympatric with *chloronotus* in central China (differing also in morphology, habitat choice and nest site). It was described as a new species, Chinese Leaf Warbler *P. sichuanensis*, though it was later realised that this name was pre-dated by *yunnanensis* (Martens & Eck 1995, P. Alström & U. Olsson unpublished).

The taxonomy of the Common Chiffchaff *Phylloscopus collybita* complex has received much attention in recent years. It was formerly considered a single polytypic species, although extensive studies of its vocalisations and other data (e.g. Martens & Hänel 1981, Martens 1982, Salomon 1987, 1989, Martens & Meincke 1989, Helbig *et al.* 1996) have led to the suggestion that at least four species ought to be recognised: Common Chiffchaff *P. collybita*, Iberian Chiffchaff *P. brehmii*, Canary Islands Chiffchaff *P. canariensis* and Mountain Chiffchaff *P. sindianus*, leaving the relationships of the Siberian taxon *tristis* unresolved (Helbig *et al.* 1996). These taxa are allopatric, except for Mountain and Common Chiffchaffs, which occur together in western Asia, and the latter meets Iberian Chiffchaff in a narrow zone in the Pyrenees. Hansson *et al.* (2000) showed that Swedish populations of Common Chiffchaff of the subspecies *collybita* and *abietinus* responded more strongly to song of their own than to the other subspecies and, based on other differences such as habitat choice, they predicted that there would be only limited hybridisation if these taxa met in the future.

The Golden-spectacled Warbler was until recently treated as a single polytypic species, *Seicercus burkii*, with a wide distribution in mountains of southern Asia (mainly the Himalayas and China). Alström & Olsson (1999, 2000) and Martens *et al.* (1999) demonstrated that this is actually a complex of no fewer than six sibling species, with up to four occurring at different altitudes on the same mountain (two, *S. soror* and *S. omeiensis*, were previously undescribed: see above). Differences in vocalisations and playback tests were of major importance in the elucidation of this situation.

Song has been used extensively in the classification of African cisticolas *Cisticola*, both to split and to lump taxa (e.g. North 1964, Chappuis 1974, 1980, Erard 1974, Morel & Chappuis 1992). Keith & Gunn (1971), Chappuis (1974–1985), Chappuis (1980) and Morel & Chappuis (1992) used vocalisations to review the taxonomy of some apalis *Apalis* species.

One remarkable case where possible cryptic species were revealed by their vocalisations is the study of North American Common (Red) Crossbill *Loxia curvirostra sensu lato* by Groth (1988, 1993a,b). He (1988, 1993a) studied a large number of individuals from across the continent, and correlated sonograms of calls with measurements of the same individuals. Based on these variables, the birds clustered into eight different groups. Several of these are sympatric, e.g. six in the Pacific Northwest. Strong assortative mating was shown to occur in two different populations in the Appalachians (1993b). He concluded (1993a) that '*L. curvirostra* is a group of sibling species' but, owing to the morphological similarity and overlap in measurements, he was unable to assign names to all of these species. The American Ornithologists' Union (1998) recognised only one species but interpreted Groth's results as indicating the probable existence of at least nine different species in North America. Studies of vocalisations by Robb (2000) have suggested that there may be cryptic species of crossbills also in Europe.

Some of the most amazing discoveries involving vocalisations involve the African indigobirds *Vidua* (e.g. Nicolai 1964, Payne 1968, 1973, 1976, 1982, 1990, 1998, Payne & Payne 1994, 1995, Payne *et al.* 1992, 1993; see above). Although most indigobird species are morphologically poorly differentiated, their songs are often markedly different. This insight has led to the recognition of several 'forms' as distinct species (all 10 indigobird species now recognised were at one time or another considered to be either subspecies or colour morphs of Village Indigobird *V. chalybeata*, or overlooked).

Crows *Corvus* are morphologically relatively poorly differentiated, but their voices are often clearly different. Vocalisations have been of major importance in the classification of the North American species American Crow *C. brachyrhynchos*, North-western Crow *C. caurinus*, Tamaulipas Crow *C. imparatus*, Sinaloa Crow *C. sinaloae* and Fish Crow *C. ossifragus* (Brooks 1942, Davis 1958, Hardy 1990).

Use of vocalisations in inferring relationships

Although vocalisations have mainly been used to answer questions of species status, some authors have used voice to judge relationships among species. In a few cases, features of songs and calls have been used as characters to infer phylogenetic relationships.

Bretagnolle (1995) compared the vocalisations of several different *Pterodroma* species and drew conclusions about their relationships based on the similarities and dissimilarities between them.

The calls of downy Anatidae young were analysed by Kear (1968), who concluded that they had phylogenetic information. The shape and frequency range of the distress call tended to be similar in closely related species and to be more divergent in more distantly related ones. For example, she remarked that the call of White-backed Duck *Thalassornis leuconotus*, whose taxonomic position had been in doubt, was 'very like those of *Dendrocygna* and quite unlike the distress call of *Oxyura*'. A recent phylogenetic analysis (McCracken *et al.* 1999) confirms that *Thalassornis* is not closely related to *Oxyura*, but also suggests that the similarity between *Thalassornis* and *Dendrocygna* is due to retention of ancestral character states in the former.

Andersson (1973, 1999) studied calls and displays of skuas (Stercorariini) and concluded that some of these are synapomorphies (shared derived characters) for Great Skua *Stercorarius skua* and Pomarine Skua *S. pomarinus*—supporting the controversial but now well-supported (see Andersson 1999) view that the latter is more closely related to the large skuas (which are often placed in the genus *Catharacta*) rather than to the smaller Arctic *S. parasiticus* and Long-tailed Skua *S. longicaudus*.

Miller (1996) used characteristics of nuptial vocalisations to infer relationships among *Pluvialis* plovers and some *Calidris* sandpipers. He also concluded that 'acoustic characters seem to have great potential for resolving species relationships at various levels' in *Gallinago* snipes and *Charadrius* plovers.

Acoustic data were used by Winkler & Short (1978) to infer relationships among pied woodpeckers (*Picoides/Dendrocopos*). In many cases, their analysis corroborated previous studies (e.g. the probable monophyly of the New World group). In other cases the vocal data were in conflict with other evidence (e.g. Middle Spotted Woodpecker *Dendrocopos medius* was considered to be more distantly related to White-backed Woodpecker *D. leucotos* than previously thought, and the same applied to Black-backed *Picoides arcticus* and Three-toed *P. tridactylus* Woodpeckers).

Vocalisations were used to determine probable relationships of some antwrens in the genus *Myrmotherula* (Whitney & Pacheco 1997). Based partly on vocalisations, Whitney (1992) suggested that Bicoloured Antvireo *Thamnomanes occidentalis* be placed in the genus *Dysithamnus* instead. Whitney & Pacheco (1994) also used vocalisations in discussing the affinities of the little-known monotypic genera *Gyalophylax* and *Megaxenops*.

Songs, calls and display flight were used in addition to other data to show the close relationship between Berthelot's Pipit *Anthus berthelotii*, endemic to the Canary Islands and Madeira, and Tawny Pipit *A. campestris* (Alström & Mild 1993), a circumstance later corroborated by molecular data (Arctander *et al.* 1996, Voelker 1999).

King (1989) showed that the different species in the genera *Tesia* and *Urosphena* clustered in two groups according to characteristics of their songs. Based on this (in conjunction with other behavioural and morphological differences) he proposed a new classification of these genera.

The relationships of various treecreepers *Certhia* have been discussed based on their vocalisations (Martens 1981, Martens & Geduldig 1988), and the affinities of Brown Creeper *C. americana* to Short-toed Treecreeper *C. brachydactyla* and Eurasian Treecreeper *C. familiaris* have recently been studied using sounds (Baptista & Krebs 2000).

The Black-collared Bulbul *Neolestes torquatus* from the Afrotropics has variously been treated as a bulbul (Pycnonotidae) or a shrike (Malaconotidae, Laniidae or Prionopidae). A recent investigation (Dowsett *et al.* 1999) used vocalisations (together with morphology and DNA) in support of the view that it is not a shrike, but most closely related to bulbuls.

Payne (1986) stated that 'similarities in song quality may express genetic similarities' even in species in which song is learned, and accordingly may be of use in phylogenetic analyses. He used vocal characters to reconstruct the phylogeny of the Black-throated Green Warbler *Dendroica virens* complex. Since his tree was largely congruent with a previous hypothesis of relationships (Mengel 1964), he concluded that 'the distribution of song traits among species indicates that cultural changes may have followed the same branching events as in the genetic differentiation of the species'.

Characteristics of song were also used by Stein (1968) to analyse relationships among North American *Vermivora* warblers.

The role of bird sound archives

Modern studies on bird vocalisations would have been impossible without the collecting of sound recordings, yet, in comparison with the collecting of physical specimens, the means to do so have been available only recently. The first recording of any bird (a captive White-rumped Shama *Copsychus malabaricus*) was made in Germany in 1889, and the first recording of a wild bird was made in England in 1900, on wax cylinders (Boswall 1969). However, it has only been in the past 40 years, long after the invention of electrical amplification and with the development of new recording technologies and the wider availability of portable, battery-operated tape-recorders, directional microphones and parabolic reflectors, that recording in the field has become truly practicable. Further refinements in recording techniques and equipment since then means that birds in any environment around the world can now be recorded relatively easily with high-quality equipment that is modestly priced, portable and reliable.

In the pre-recording era, the value of vocalisations for identifying and classifying birds was well known. But a far more detailed scrutiny of bird sounds has become possible with technological advances. Sound recordings have multiple applications, not only in taxonomic research: they reveal the structure of sounds, and facilitate their description and comparison between different populations and species, while playback experiments can test reactions of birds to answer questions about song function, or to identify and draw out hidden birds for identification in faunal surveys (Johnston *et al* 1981, Parker 1991) as well as identifying individual birds (e.g. McGregor 1992). Recordings are used by birdwatchers and field researchers for familiarisation of species' diagnostic sounds, a key factor in efficiently determining their ranges in a short time-frame (Parker 1991); to help trap birds for ringing and relocation projects; to help deter pest species from urban areas, agricultural crops and airports; in educational programmes in museum and zoo exhibitions, audio and multimedia publications and websites, and in television and radio broadcasts.

The emerging science of bioacoustics received a boost after Thorpe's (1954) use of the sound spectrograph to analyse and compare Chaffinch *Fringilla coelebs* songs. Originally developed as a speech aid for the deaf (Potter *et al.* 1947), the sound spectrograph allowed more rapid and objective description and comparison of bird vocalisations.

The first archive of bird sounds was formed from a collection originally started in 1932 at Cornell University in the USA (Gulledge 1979). There are now numerous

TABLE 1

Major institutional bird sound archives, based upon Kettle (1989) with updated figures from archive curators (*in litt.*).

	Location	**Year established**	**Number of bird species represented**	**Total number of bird recordings**	**Collection strengths**
Macaulay Library of Natural Sounds	Cornell University, New York state, USA	1956	6,400	130,000	Worldwide, especially neotropics
British Library National Sound Archive	London, England	1969	7,800	120,000	Worldwide
Tierstimmenarchiv	Humboldt University, Berlin, Germany	1952	1,800	100,000	Central Europe, Mongolia
FitzPatrick Bird Communication Library	Transvaal Museum, Pretoria, South Africa	1979	3,000	30,000	Africa
Australian National Wildlife Collection Sound Library	CSIRO, Lyneham, Australia	1961	400	25,000	Australasia
Borror Laboratory of Bioacoustics	Ohio State University, USA	1945	876	21,000	USA
Florida Museum of Natural History	Florida, USA	1973	2,700	15,000	USA and neotropics
Arquivo Sonoro Neotropical	Campinas University, São Paulo, Brazil	1978	1,000	12,000	Brazil

institutional collections worldwide (Kettle 1989; see also Frommolt 1996, Nelson & Gaunt 1997, Ranft 1997); however, only the eight largest collections (Table 1), which altogether hold around half a million recordings, receive public funding to ensure the long-term preservation of and access to the recordings in their care. These collections have been built up mainly through the donations from many scientists and recordists, and they represent many hundreds of thousands of hours of work in the field. As with traditional museum collections of bird skins, they are invaluable especially for comparative studies between individuals, populations and species where it is often impossible for one person to replicate, even in a lifetime of work, the dedicated efforts of so many collectors of sounds.

The rapid growth in systematic collections of bird sound recordings has been encouraging and the value of this material is now widely appreciated (Parker 1991, Kroosdma *et al* 1996). Some of the challenges these collections are faced with are discussed below.

(1) There is an urgent need to add many more recordings to these collections. Comparative studies of bird sounds usually require a large sample of recordings from different localities. Yet even for well-recorded species there are many gaps in geographical range (see, e.g., Kroodsma *et al.* 1996). As expected, the tropical regions are the most inadequately covered, with many species represented by few recordings often from a single, well-studied site, or by single recordings from widely scattered localities or even simply by a single recording. Many recordings exist in private collections without adequate access or long-term preservation (Kroodsma *et al* 1996, Harrington 1997). To deal with all the extra recordings, however, requires a substantial effort on the part of the recordists, and of course a commitment of resources by the archives, some of which are seriously underfunded. Publishing recordings on cassettes and CDs or on the internet is a useful way to make them widely accessible but this is not a solution to their long-term availabilty: recordists should be urged to commit their recordings to archival facilities.

The vocalisations and behaviour of many species of bird, especially tropical songbirds, are so poorly known that it may be difficult to judge whether variation between individuals or populations is of taxonomic significance or merely indicative of a rich repertoire. Large samples of recordings can help assess such variation. An analysis of the catalogues from the major sound collections, and many other smaller private collections, reveals that there are no recordings at all of around 940 species of bird, or nearly 10% of the total. Over 100 of the missing species are hummingbirds (Trochilidae). For taxa currently treated as subspecies, the situation is much worse. For example, based primarily on morphological differences, Collar & van Balen (2002) suggested that the Blue-tailed Trogon *Apalharpactes reinwardti* is better treated as two species, Javan Trogon *A. reinwardti* and Sumatran Trogon *A. mackloti*; the Javan form apparently lacks the distinctive song of the Sumatran one, but the paucity of recordings from Java meant that vocalisations were not conclusive in supporting the rearrangement. Similarly, Garrido *et al.* (2002) judged the Hispaniolan and Cuban forms of Grey-headed Quail Dove *Geotrygon caniceps* to be sufficiently different morphologically to be treated as different species, but they lacked examples of the song of the Hispaniola race to support their contention.

(2) Recordings need to be of the highest technical quality to be of full value for analysis. C. Chappuis (*in litt.*) has remarked that the speed of cassette recorders is often wrong, and suggested that a reference sound (e.g. from a tuning fork) should be recorded in the field. A frequent problem when making sonograms of recordings is that the sounds of interest are obscured by background noise, or reverberation from vegetation. Recordings should ideally be made with the microphone as close as possible to the subject, using well-maintained professional audio recording equipment. Nevertheless, a great deal of useful information can often be extracted from a poor recording. For example, computer techniques have improved the quality of a unique recording of the almost extinct Slender-billed Curlew *Numenius tenuirostris* that was otherwise nearly obliterated by a louder and similar song of a Eurasian Curlew *N. arquata* (Chappuis 2000). Further advice on recording can be obtained from the major sound archives.

(3) The paucity of collection data associated with each recording needs to be addressed. A recording must be accompanied with data collected at the time it was made, including locality, time of day, date and other details. The more complete the data, the more applications the recording will have for future researchers. As with skin collections, missing or insufficient locality data in bioacoustic collections can reduce their value. Efforts have been made recently to encourage the standardisation of data collection (see Kettle & Vielliard 1991, Bradbury *et al.* 1999).

(4) Certain identification of the species involved is required. Few sound recordings are associated with skin specimens, so that corroboration of their identity depends either on the skills of the original recordist or matching against known reference recordings, which may of course also be unreliable (see, e.g., Payne 1973a, 1982, 1998 for recordings linked to museum specimens). There are several instances of rare recordings that were for some years archived as authoritative recordings and published as such, only later to be found to have been misidentified. For example, a recording of the Boreal Owl *Aegolius funereus* erroneously attributed to Northern Hawk Owl *Surnia ulula* was published in several American and Swedish identification guides in the period 1960–1980 (Hardy *et al.* 1989). Similarly, Wahlström (1968) revealed that a recording made in 1948 and published several times in Europe until 1968 as the voice of Baillon's Crake *Porzana pusilla* was in fact that of Little Crake *P. parva*.

(5) Sound archives need to be able to share and make more widely available their collections. All the largest archives can provide basic inventories of their holdings. But so far just two archives, the Borror Laboratory and The British Library's National Sound Archive, have their full catalogues on the internet (see http://blb.biosci.ohio-state.edu/BLBCatalog.htm and http://cadensa.bl.uk/). These catalogues contain full details about recordings, but not the actual sounds. Sound recordings can be easily replicated and distributed over digital networks such as the internet, and several audio archives are presently implementing the means to enable

worldwide direct access to at least parts of their collections over the internet. A large-scale roll-out of these collections depends on the resolution of technical and copyright issues, in particular achieving the right balance between safeguarding the unauthorised use of recordings and providing unrestricted access, and allowing access to sounds over a worldwide web that is currently too slow for rapid distribution of high-quality audio files.

Discussion and conclusions

We have firmly established that acoustic signals have been of great use in a wide range of birds in (1) the discovery of new species, (2) the assessment of taxonomic rank of allopatric taxa under the biological species concept (Mayr 1942) and (3) phylogenetic analyses. The importance of vocalisations in the discovery of new species is now widely acknowledged, and it seems likely that more sibling species will be discovered in the future as a result of thorough vocal analyses, especially in geographical areas that have been poorly surveyed. However, it seems unlikely that such discoveries will substantially increase the total number of bird species.

By contrast, growing knowledge of the vocalisations of different taxa (which is largely due to the increased use of tape-recorders and sound analysis software, and the greater ease of travel in recent years), in combination with the current trend to afford species status to allopatric taxa with distinctive vocalisations, will probably produce a steady increase in the number of recognised species. A large proportion of all bird taxa (estimated at 27,000–28,000 by Mayr & Gerloff 1994) is poorly known with respect to their vocalisations, and the taxonomic status of many of these will undoubtedly be re-evaluated when their voices become better known. It is thus vital that more taxa are tape-recorded, especially those that are currently treated as subspecies, and that recordings are properly documented, curated and made accessible.

All bird species produce sounds (even the New World vultures Cathartidae, which lack a syrinx, make functional sounds). Songs, in particular, are usually fairly loud and hence can be detected and recorded from a distance without disturbance. For birds that are difficult to observe, i.e. nocturnal or cryptic species, or those occurring in dense habitats such as forests and reedbeds, recordings may be the only convenient method of data collection. The usefulness of recordings in systematic research has increased in recent years since (a) recordings are relatively easy and cheap to collect, preserve, replicate and share; (b) there is an existing extensive dataset of bird recordings in sound archives to draw upon; and (c) tools such as computer software for sound analysis are now cheap and widely available.

There is still a need to refine and standardise the methodology for employing sound recordings as a systematist's tool. Such an attempt was made by Isler *et al.* (1998), who analysed vocalisations of eight syntopic, similar-looking and similar-sounding antbird species (Thamnophilidae). Based on this, they proposed that when deciding the rank of allopatric antbird taxa, three diagnosable vocal characters (the minimum number that distinguished the syntopic pairs in the study) should be used as a point of reference. They recommended that for taxa that are very poorly differentiated in other respects, more than three vocal characters are required to allow classification as species, whereas for taxa that differ strongly in other ways, fewer vocal characters may suffice.

Finally, sounds alone should not be used in making taxonomic decisions. However, they can be a first pointer to the field ornithologist to gather additional evidence such as further morphological, DNA or behavioural data, and these data can then be used in conjunction in taxonomic revisions.

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Museums on paper: library & manuscript resources

by C. T. Fisher & F. E. Warr

SUMMARY

A natural history museum collection typically houses a great deal of paper-based material (additional to specimen labels) that may directly or indirectly relate to specimen material in its own, or other, establishments. This material may be of great value to the study of natural history and the promotion of conservation. Amongst the documentation most useful in ornithology are field and museum labels, field notes and reports, itineraries, diaries, letters, stock books, annotations in catalogues, and captive breeding records. Among the figurative materials of great potential value are field sketches, drawings and photographs, any of which may relate to the history of a specimen, species or habitat. We exemplify these uses and values, drawing on cases involving mainly rare or extinct species (in order of appearance: *Vanellus macropterus*, *Amaurocichla bocagei*, *Diaphorapteryx hawkinsi*, *Psephotus pulcherrimus*, *Pinguinus impennis*, *Cistothorus platensis*, *Calidris ferruginea*, *Haliaeetus albicilla*, *Melopsittacus undulatus*, *Rhodonessa caryophyllacea*, *Sceloglaux albifacies*, *Rallus nigra*, *Janthoenas godmani*, *Cuculus poliocephalus*, *Sitta longirostris* and *Tympanuchus cupido*). However, paper-based museum resources also have great potential for such studies as those which help delineate the extent and nature of population declines in common birds. These resources need to be better known by and more accessible to scholars.

Introduction

Most people think of museums solely as repositories for three-dimensional specimens (such as Greek pots, Roman coins or bird skins) and two-dimensional works of art on canvas and paper. In fact, there are many other items on paper that are just as important to preserve. Museums—including natural history museums—often house considerable collections of paper-based material. These collections can be broadly divided into archival matter (paper which the institution itself has produced, such as foundation documents, stock books, correspondence files, biographical information, photographic records of staff and events, records of financial matters), manuscripts (written items considered worth preserving in their own right) and works of art on paper. Large museums (such as the Natural History Museum in London, the Australian Museum in Sydney, or Naturalis in Leiden) have large departments of library and archive services to look after such material, and the curatorial staff regard these departments as a core function of their institution.

The preservation of original paper-based material relating to ornithology—whether writing, picture or photograph—is just as important as biological material for the study, particularly historical, of birds. Such records are especially useful for the safe keeping of knowledge about those species that are now extinct or endangered, and in many cases provide the only record of extinct species. All biological bird material is to a considerable degree devalued if it is dissociated from originally accompanying (or, indeed, subsequently provided) written, drawn or photographic material. In this paper we identify and illustrate some of the types of contribution to ornithology and conservation made by the paper archives maintained by museums.

Written material

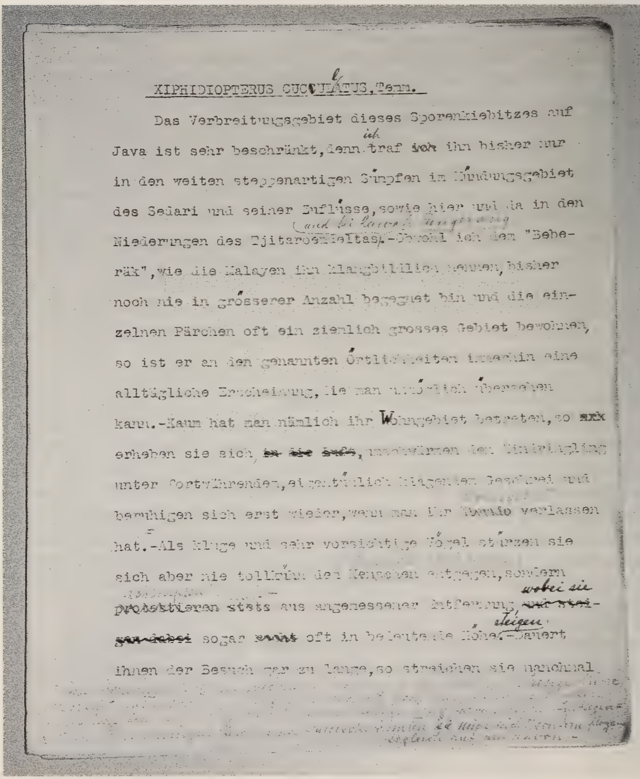
Amongst the written materials most useful in ornithology are: field and museum labels, field notes and reports, itineraries, diaries, letters, stock books and annotations in catalogues, and captive breeding records. In this essay we largely assume the crucial importance of ensuring the permanent attachment and good condition of original specimen labels as a means of verifying and evaluating specimen material, but we do allude to cases which demonstrate this particular truth. It is also to be noted that the preservation and improvement of label *condition* are well worthy of the close attention of the museum curatorial community. We also assume the obvious necessity of regarding biological field records as specimens in their own right, and would like to emphasise that when these are on computer, rather than on file cards, it is nevertheless both practical and precautionary to keep hard copies, since members of the public may not always have computer access at the time of their visit. Furthermore, we assume that the need for an accurate and detailed paper catalogue or register of all specimen material in a particular institution is acknowledged and understood (although it is apparent that the development of such documents into computerised format remains a challenge of very considerable dimensions, as it does for other paper-based materials). For the most part we use this essay to furnish some noteworthy examples of how paper-based materials have yielded significant pieces of information in ornithology.

Field notes, 1: Bartels on the Javan Lapwing

Max E. G. Bartels was a plantation owner on Java who had a great love of birds both in the wild and in the aviary. His detailed field notebooks, written between 1915 and 1931, are held in the Rijksmuseum van Natuurilijke Historie (Naturalis), Leiden, the Netherlands. Bartels's notes include an account of the Javan Lapwing *Vanellus macropterus*, which is possibly now extinct. This is the only known field description of the species, without which absolutely nothing would otherwise be known about it in the living state. This account has been recently published (Collar *et al.* 2000) but some extracts follow:

> *Xiphidiopterus cucullatus*, Temm.
> The area of distribution of this Spurred Lapwing in Java is very restricted ... found … only in the extensive steppe-like swamps of the Sedari estuary and its tributaries, as well as… in the lowlands of the Tjitaroem delta and at Rawah Tangerang… [where] it is an everyday sight, impossible to miss… As they are clever and very cautious birds, they never dive-bomb people but instead they generally 'create a stink' at an appropriate distance… During the east monsoon… they undoubtedly prefer the patches where [Teki] grasses stay moist the longest… During the rainy season the birds keep to areas in the swamps which are relatively little flooded, since despite their long legs they prefer not to walk in open water

like stilts. In the Tjitaroem delta they often busy themselves in wet cattle pasture at the borders of their normal foraging areas, which are densely overgrown swamps with rush/sedge and other shorter water plants… Their food consists mainly of water- or swamp-living insect larvae, water bugs, beetles, snails… and seed of aquatic plants… (Fig. 1).



XIPHIDIOPTERUS CUCULLATUS,Temm.

Das Verbreitungsgebiet dieses Sporenkiebitzes auf Java ist sehr beschränkt, denn ich traf ~~ich~~ ihn bisher nur in den weiten steppenartigen Sümpfen im Mündungsgebiet des Sedari und seiner Zuflüsse, sowie hier und da in den (und bei [illegible]) Niederungen des Tjitaroemdeltas. - Obwohl ich den "Beberäk", wie die Malayen ihn klangbildlich nennen, bisher noch nie in grösserer Anzahl begegnet bin und die einzelnen Pärchen oft ein ziemlich grosses Gebiet bewohnen, so ist er an den genannten Örtlichkeiten immerhin eine alltägliche Erscheinung, die man unmöglich übersehen kann. - Kaum hat man nämlich ihr Wohngebiet betreten, so ~~sxx~~ erheben sie sich ~~in die Luft~~, umschwärmen den Eindringling unter fortwährendem, eigentümlich klagendem Geschrei und beruhigen sich erst wieder, wenn man ihr [illegible] verlassen hat. - Als kluge und sehr vorsichtige Vögel stürzen sie sich aber nie tollkühn dem Menschen entgegen, sondern ~~protestieren~~ stets aus angemessener Entfernung, wobei sie ~~und stei-gen dabei~~ sogar ~~auch~~ oft in bedeutende Höhe steigen. - Dauert ihnen der Besuch gar zu lange, so streichen sie manchmal

Figure 1. Account of the Javan Lapwing, from Max Bartels' field notes (© Naturalis, Leiden).

Field notes, 2: Correia and the São Tomé Short-tail

When working on *Threatened birds of Africa and related islands* (Collar & Stuart 1985), N. J. Collar noticed that David Bannerman, in *Birds of the Atlantic islands*, made repeated reference to notes on species made by J. G. Correia during collecting work he undertook for the American Museum of Natural History on the Azores and Cape Verdes. In 1928–1929 Correia had also collected on the islands of São Tomé and Príncipe (Amadon 1953)—islands of immense importance to conservation yet in the early 1980s still virtually unknown biologically—so Collar (verbally 1999) made inquiries at AMNH whether Correia had left any notes there on his work. Initially Mary LeCroy was unable to find anything, but eventually a typescript came to light in Dean Amadon's desk and was copied to Collar for his use. The value of this typescript is to some extent limited by the fact that Correia, understandably, was not entirely sure of what he was seeing, and so named the birds he saw in accordance with his sense of what they might be ('Yellow-bellied Flycatcher' and so on). Nevertheless, once these names can be identified with complete confidence, by relating dates in the typescript to dates on specimen labels, the manuscript has great potential to illuminate species' former abundance and habits.

Perhaps the most remarkable entry in the typescript concerns *Amaurocichla bocagei*, to which Collar & Stuart (1985) gave the name São Tomé Short-tail, since no-one then was very sure what it was (although the Abbé René de Naurois had just sent Collar a manuscript in which he proposed the *possibility* that the species was the Old World's only furnariid). At the time of Correia's visit, the bird was only known from three nineteenth-century specimens, and it was only by obtaining the dates of the specimens Correia collected and matching them to his notebook entries that it was possible to identify the subject of the entry. His entry for 4 December 1928 (reproduced exactly as typed) show that the bird did indeed present a striking problem of taxonomic placement:

> No rain in the morning but dark weather; I went up to the Obó (forest) for my good luck I foudn two new birds to-day Rail. a new bird for me and for the residentes of these part of the island which told me that they as never seen such bird yet. The Rail is a very small bird the back is dully brown and the belly is ruffs brown very shirt tail but litle long legs with long toe too. I found its on the creek quite at the head of the Rio Quija, its was on the small stones in the centre of the creek looking for some thing among the sand, when I shot the first an other took a short flight and restd on a dry limb right among the stones so I shot it too. Its were male and famely. I shot one Yellow-belly, one Ossobo, and three large honey-eaters all in the Obó excpet the Ossobo.

Of course the species is *not* a rail (it appears to be an aberrant sylviid). However, Correia's observations of its rail-like behaviour were an important insight into its ecology and helped guide researchers when they became the first people since Correia (and, at that time, the only others last century) to see the species in the wild (Atkinson *et al.* 1991).

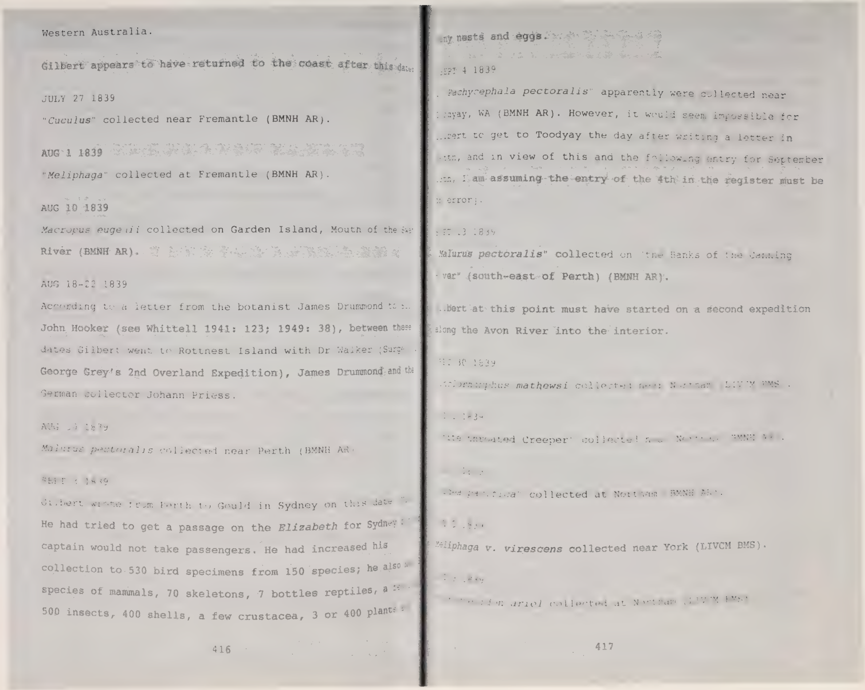
Itineraries

It is obviously imperative for collectors to keep accurate records of where and when specimens were collected in the field, and that these data are permanently attached to the specimen. Eighteenth- and nineteenth-century specimens on the whole lack this depth of information, and it is often only by recourse to original diaries and expedition reports that information can be reunited with specimens. Conversely, labels with data can be very usefully employed to create a diary for an explorer where this does not exist, or has been lost. In the Victorian period, in particular, the custom was for dispersal of specimens from a particular expedition to museums around the world (in essence to whomsoever would pay for them). Databasing the locality and dates on these specimens, after searching them out in the many museums which contain good Victorian natural history collections, can give unexpectedly positive results. These are not only of biographical interest: Australians, for instance, have found the database and itinerary compiled by the Liverpool Museum about John Gilbert's travels in Australia between 1838 and 1845 (housed in computer form, as a card index and as numerous notes and photocopies, which indeed fill the shelves of one whole office) essential for confirming exactly where he had collected some of his rarest species (see below). In many cases a specimen with a missing or obscured collecting date can be checked against another with the same locality; conversely specimens with dates but no localities can be reunited with place names when compared to other specimens collected on the same day (Fig. 2).

Rasmussen & Prŷs-Jones (2003, this issue) also refer (in their section 'Label substitution') to the use archival material can make in determining provenance of suspect material (e.g. Meek's 'Misima' material) and to the frustration of science that results from the loss of archival material (e.g. the ill-considered destruction of many of Rothschild's papers).

Letters: Dannefaerd on the Giant Chatham Island Rail

The Giant Chatham Island Rail *Diaphorapteryx hawkinsi* is only known from fossil bones first collected in 1892 by W. Hawkins (for whom the bird is named). However, a letter (from Auckland, dated 21 February 1895) held in the Rothschild Correspondence archive at the Natural History Museum, London, from Sigvard Dannefaerd to his employer Walter Rothschild, includes unique observations on the living rail and other bird species that Dannefaerd gleaned second-hand during a visit to the native Chatham Island Morioris. The Giant Rail became extinct before the arrival of Europeans in the mid-1800s, but obviously coexisted with the Moriori for some time. However, the abundance of its remains in Moriori middens indicates that it was frequently hunted as food, an interpretation corroborated emphatically by the information in Dannefaerd's letter. A full description of the letter and its significance is being prepared by Joanne Cooper of the Natural History Museum, Tring, as part of a wider survey of Rothschild's Chatham island collections. There is an artist's reconstruction of the Giant Chatham Rail in Gill & Martinson (1991: Figure 18), and a complete skeleton of a bird collected by Dannefaerd for Rothschild was illustrated in Andrews (1896: plate XII).



Western Australia.

Gilbert appears to have returned to the coast after this date.

JULY 27 1839

"*Cuculus*" collected near Fremantle (BMNH AR).

AUG 1 1839

"*Meliphaga*" collected at Fremantle (BMNH AR).

AUG 10 1839

Macropus eugenii collected on Garden Island, Mouth of the Swan River (BMNH AR).

AUG 18-22 1839

According to a letter from the botanist James Drummond to [illegible] John Hooker (see Whittell 1941: 123; 1949: 38), between these dates Gilbert went to Rottnest Island with Dr Walker (Surgeon [illegible] George Grey's 2nd Overland Expedition), James Drummond and the German collector Johann Priess.

AUG [illegible] 1839

Malurus pectoralis collected near Perth (BMNH AR).

SEPT [illegible] 1839

Gilbert wrote from Perth to Gould in Sydney on this date [illegible] He had tried to get a passage on the *Elizabeth* for Sydney [illegible] captain would not take passengers. He had increased his collection to 530 bird specimens from 150 species; he also [illegible] species of mammals, 70 skeletons, 7 bottles reptiles, a [illegible] 500 insects, 400 shells, a few crustacea, 3 or 400 plants [illegible]

416

[illegible] nests and eggs.

SEPT 4 1839

"*Pachycephala pectoralis*" apparently were collected near [illegible]yay, WA (BMNH AR). However, it would seem impossible for [illegible]bert to get to Toodyay the day after writing a letter in [illegible]th, and in view of this and the following entry for September [illegible], I am assuming the entry of the 4th in the register must be [illegible] error).

SEPT 13 1839

"*Malurus pectoralis*" collected on "the Banks of the Canning [illegible]ver" (south-east of Perth) (BMNH AR).

[illegible]bert at this point must have started on a second expedition along the Avon River into the interior.

[illegible] 30 1839

[illegible] *mathewsi* collected near Northam (LIVCM BMS).

[illegible]

"[illegible] Creeper" collected [illegible] Northam (BMNH AR).

[illegible]

"[illegible]" collected at Northam (BMNH AR).

[illegible]

"*Meliphaga v. virescens* collected near York (LIVCM BMS).

[illegible]

[illegible] *ariel* collected at Northam (LIVCM BMS).

417

Figure 2. Part of John Gilbert's itinerary in Australia, reconstructed from specimen labels, letters, diaries and published accounts (from Fisher 1992, © NMGM).

This is not the only scientifically interesting letter amongst Dannefaerd's correspondence, which is also greatly revealing about how extensive Dannefaerd's previously unrecognised contribution to Rothschild's fossil collection was.

Letters and field labels: Gould, Gilbert and the Paradise Parrot

The Paradise Parrot *Psephotus pulcherrimus* was first collected on the Darling Downs of southern Queensland by John Gilbert, John Gould's collector in Australia, in May 1844. Gilbert wrote to tell Gould about his new bird, which is now thought to be extinct (Brooks 2000). The story of Gilbert's discovery is now known only because of the finding of two letters, the first in 1938. This was a draft[1] of Gould's reply to Gilbert's letter, found in an old trunk belonging to Gould's descendants. In this letter Gould exclaimed 'I am especially delighted about the new *Platycercus*...'

Since then it has been suspected that Gould had used Gilbert's account, as contained in his original, but lost, letter, to help compose the type description of the Paradise Parrot (Gould 1845). Luckily, a copy of Gilbert's original letter was quite recently found in Liverpool City Libraries[2] (Fisher 1985) (Fig. 3). The copy was by the 13th Earl of Derby, an ardent amateur ornithologist, to whom Gould was hoping to sell some specimens of this spectacular new parrot—hence he had obviously lent Gilbert's letter to Lord Derby as an encouragement. Lord Derby was an inveterate copier of letters (many into copybooks, although this copy is loose) but was not always punctilious about returning them. It seems he never sent the original of Gilbert's letter back to Gould and it cannot now be found. This means Lord Derby's copy is the only record of the collection of the first specimens of this now extinct species, and confirms that Gilbert's description in the letter *was* used by Gould for the type description. In fact, most of the type description was lifted word-for-word from Gilbert's letter, as this extract demonstrates:

> I ... seize the opportunity of writing to you a few observations... almost the first bird shot is a totally new parrot...without exception the most beautiful of the whole tribe I have ever yet seen in Australia... the mingling of the beautiful shades of green, is its most conspicuous and beautiful character... it is in habits truly a grass-eating Parrot, assembling in small families and feeding in high grass...

Gould succeeded in selling two of Gilbert's specimens of the Paradise Parrot to Lord Derby. Both still have Gilbert's original field labels attached to them[3]. The hand-written collecting date on the label attached to one of these specimens predates Gilbert's letter. This bird, a fine male[4], must therefore be considered to be from the original type series. The fact that it still has Gilbert's original label (Fig. 4) gives us locality detail missing from the designated type specimens in the Academy of Natural Sciences, Philadelphia, as most of these have had their original field labels removed. Gilbert's letter and label details, coupled with research which has pinpointed Gilbert's route and dates as he travelled through the Darling Downs (see 'Itineraries' and 'Diaries'), means that the original location of the discovery of the Paradise Parrot can now be accurately recorded.

This shows how imperative it is for specimen labels to be carefully looked after. National Museums & Galleries on Merseyside (NMGM), recognising this fact, have started a programme of conserving bird skin labels, which are cleaned, mended and encapsulated in plastic sheaths before being re-attached (see Fig. 4). The conservation project is being undertaken by Paper Conservation staff of the Conservation Centre Division of NMGM, in conjunction with their Organics Conservation staff, who

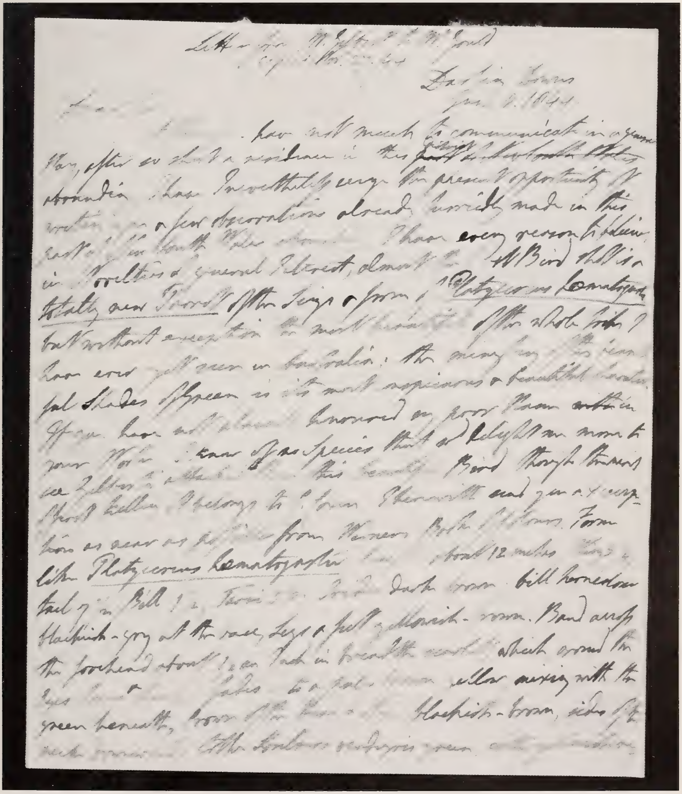


Figure 3. First page from Lord Derby's copy of John Gilbert's letter, in which Gilbert told John Gould about the discovery of the Paradise Parrot (© Liverpool City Libraries).

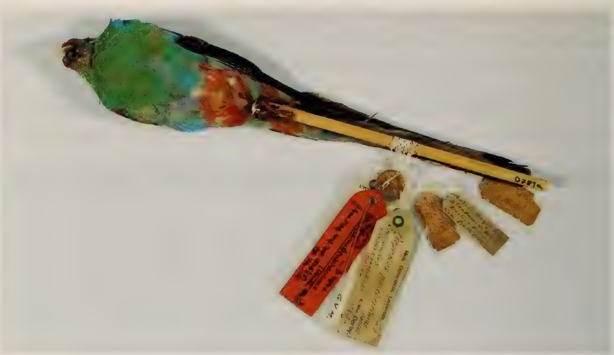


Figure 4. Labels on Liverpool Museum's paratype of the Paradise Parrot, which include Gilbert's original collecting label. Note that all the labels have been encased in protective plastic (© NMGM).

first repair the cabinet skin. In addition, they insert a dowelling rod into the skin to make a stronger base not only for the body, but for the attachment of legs and labels; these can be tied to the rod and extra stability provided by winding cotton round the legs and through a small drilled hole.

Diaries: Gilbert on the Leichhardt Expedition 1844–1846

The discovery of the Paradise Parrot can also be used to illustrate the importance of daily diaries, which were often kept by naturalists and explorers. Practically all that is known about the range of the Paradise Parrot in the 1840s has been extracted from the labels on John Gilbert's specimens and from remarks he made in his diary, begun during his solo expedition through the Darling Downs area from May 1844. His diary continued after he joined the Second Leichhardt Expedition. The expedition members aimed to cross Australia from southern Queensland to Port Essington, on the north-west coast; Gilbert was a member of the expedition from October 1844 to June 1845, when he was killed by Aboriginals in northern Queensland (Fisher 1985).

The Paradise Parrot is first mentioned when Gilbert collected specimens in the Condamine River area of the Darling Downs, but he also noted the bird several times in his diary as the Leichhardt Expedition travelled north through Expedition Range and up the Comet River. His last recorded sighting of it was in June 1845 at the Mitchell River, over 600 miles north of the Darling Downs, just before he was killed (Chisholm 1945, Fisher 1985). These diary entries extend the known range of the Paradise Parrot much further to the north than would otherwise have been suspected, and give conservationists a better chance of rediscovering this beautiful species, which was last seen in the wild in 1927 (Schodde & Tidemann 1986).

Gilbert's diary is very difficult to read (Fig. 5), but it is remarkable that it survived at all. It was eventually returned to John Gould by Ludwig Leichhardt after the rest

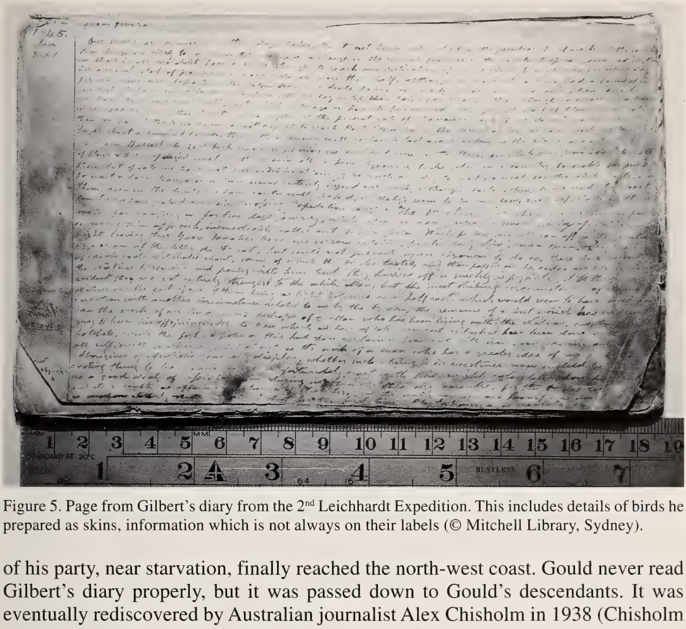


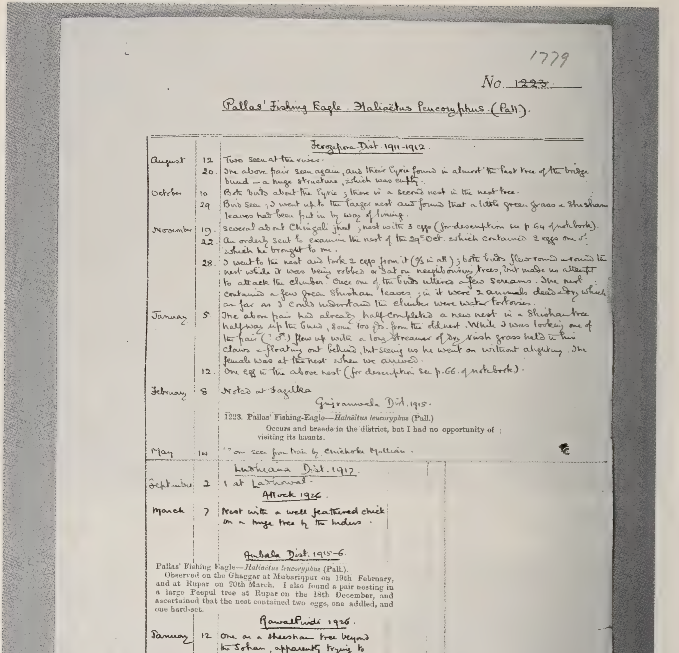
Figure 5. Page from Gilbert's diary from the 2nd Leichhardt Expedition. This includes details of birds he prepared as skins, information which is not always on their labels (© Mitchell Library, Sydney).

of his party, near starvation, finally reached the north-west coast. Gould never read Gilbert's diary properly, but it was passed down to Gould's descendants. It was eventually rediscovered by Australian journalist Alex Chisholm in 1938 (Chisholm 1945) and is now in the Mitchell Library in Sydney[5]. It is presently being transcribed for publication, with Gilbert's comments on the birds he collected being matched (where possible) with the specimens that survive in several museums. This is only possible because many of these specimens still bear Gilbert's original field labels.

Compilations: the Whistler–Ticehurst notes, and the Great Auk Scrapbook

Natural historians interested in their subjects sometimes compile scrapbooks or working collections of notes. These often include unpublished material, or material that would otherwise most probably have been missed.

Hugh Whistler and Claud Ticehurst compiled a huge collection of notes and illustrations for a proposed book on the birds of India, a project never fulfilled owing to their untimely deaths. They tried to gather together all the available information, which involved cutting and pasting published information and adding remarks of their own. The compilations were extensively used by Ali & Ripley in their own ten-volume *Handbook of the birds of India and Pakistan* (1968–1974). They did not use all the information, however, and much unpublished material remains amongst



1779

No. ~~1223~~.

Pallas' Fishing Eagle. Haliaëtus leucoryphus. (Pall.).

Ferozepore Dist. 1911-1912.

August 12 Two seen at the river.

20. The above pair seen again, and their Eyrie found in almost the last tree of the bridge bund — a huge structure, which was empty.

October 10 Both birds about the Eyrie; there is a second nest in the next tree.

29 Bird seen; I went up to the larger nest and found that a little green grass & Shisham leaves had been put in by way of lining.

November 19. Several about Chingali jheel; nest with 3 eggs (for description see p. 64 of notebook).

22. An orderly sent to examine the nest of the 29th Oct. which contained 2 eggs one of which he brought to me.

28. I went to the nest and took 2 eggs from it (c/3 in all); both birds flew round & round the nest while it was being robbed or sat on neighbouring trees, but made no attempt to attack the climber. Once one of the birds uttered a few screams. The nest contained a few green Shisham leaves; in it were 2 animals dead & dry which as far as I could understand the climber were water tortoises.

January 5. The above pair had already half completed a new nest in a Shisham tree halfway up the bund, some 100 yds. from the old nest. While I was looking one of the pair (? ♂.) flew up with a long streamer of dry rush grass held in his claws & floating out behind, but seeing us he went on without alighting. The female was at the nest when we arrived.

12. One egg in the above nest (for description see p. 66. of notebook).

February 8 Noted at Fazilka

Gujranwala Dist. 1915.

1223. Pallas' Fishing-Eagle—*Halaëitus leucoryphus* (Pall.)

Occurs and breeds in the district, but I had no opportunity of visiting its haunts.

May 14 ?? one seen from train by Chichoki Mallian.

Ludhiana Dist. 1917.

September 2 1 at Ladhowal.

Attock 1926.

March 7 Nest with a well feathered chick on a huge tree by the Indus.

Ambala Dist. 1915-6.

Pallas' Fishing Eagle—*Haliaëtus leucoryphus* (Pall.).

Observed on the Ghaggar at Mubariqpur on 19th February, and at Rupar on 20th March. I also found a pair nesting in a large Peepul tree at Rupar on the 18th December, and ascertained that the nest contained two eggs, one addled, and one hard-set.

Rawalpindi 1926.

January 12 One on a sheeshan tree beyond the Sohan, apparently trying to break off sticks.

Haliaëtus leucoryphus 1779 ~~1223~~.

8/xi/21. one on Beas at Sujanpur: well known as 'Kol' to Shikari with me who described its nesting site on a Simal tree.
9/2/22. one at Chakki.
3/3/22. ? seen at Chakki.
20-21/10/22. several along river between Hajipur & Indaura & eyrie at Indaura.
22/1/23. one at Baroli.
27/1/23. 1 between Barsar & Hamirpur.

Figure 6. A page from the Whistler-Ticehurst notes, with information on Pallas's Fish Eagle *Haliaetus leucoryphus* (© The Natural History Museum, London).

the Whistler–Ticehurst manuscripts. These are still used by visiting naturalists using the Ornithology Library at Tring, where they are now kept (Fig. 6). The page illustrated also shows the damage that rusting metal pins cause to manuscripts; librarians now use plastic, or plastic-coated, paper clips.

The Great Auk Scrapbook is an unpublished single-copy compilation, originally from the library of Colonel Hanbury Barclay, who made a handwritten index of the contents. In 1911 the scrapbook was sold at auction and it passed into the possession of Thomas Parkin, who continued the collection of printed papers, and added letters, press-cuttings and photographs concerning sales of Great Auk *Pinguinus impennis* relics. The Natural History Museum purchased the scrapbook in 1961[6]. This collection of published and unpublished snippets on the Great Auk has proved very useful to many researchers (Fig. 7).

Annotated catalogues and associated manuscripts: Sharpe and Darwin

Staff at the Natural History Museum have been trying to match all Charles Darwin's bird specimens that are now in their collections against his original field notebooks. The museum's published bird *Catalogue* (Sharpe 1881: 244-245) lists their specimens of Sedge Wren *Cistothorus platensis* from the Falkland Islands. However, the annotations in the working library copy of this catalogue at the NHM's outstation at Tring[7] are much more revealing than the printed text, as details of several specimens have been added in manuscript in the opposite margin. These skins had been added

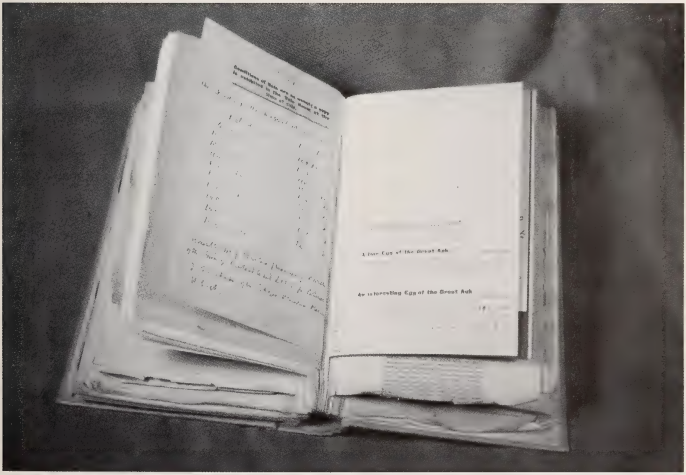
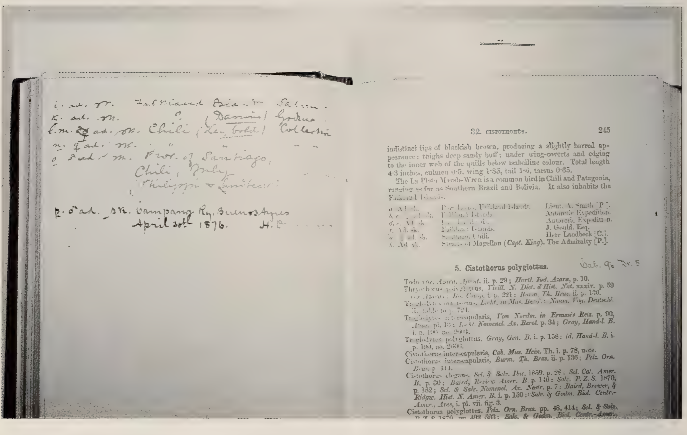

A fine Egg of the Great Auk
An interesting Egg of the Great Auk

Figure 7. The Barclay-Parkin Great Auk Scrapbook (© The Natural History Museum, London).



i. ad. m. Falkland Isl. Salvin.
k. ad. m. ? (Darwin) Godman
l.m. ♀ ad. m. Chili (Leybold) Collectn
n. ♀ ad. m. " " " "
o ♀ ad. m. Prov. of Santiago,
Chili, July
(Philippi & Landbeck)

p. ♂ ad. sk. Campana Ry. Buenos Ayres
April 30th 1876. H.

32. CISTOTHORI. 245

indistinct tips of blackish brown, producing a slightly barred appearance: thighs deep sandy buff; under wing-coverts and edging to the inner web of the quills below isabelline colour. Total length 4·3 inches, culmen 0·5, wing 1·85, tail 1·6, tarsus 0·65.

The La Plata Marsh-Wren is a common bird in Chili and Patagonia, ranging as far as Southern Brazil and Bolivia. It also inhabits the Falkland Islands.

a. Ad. sk.	[illegible], Falkland Islands.	Lieut. A. Smith [P.].
b, c. [illegible]	Falkland Islands.	Antarctic Expedition.
d, e. [illegible]	[illegible]	Antarctic Expedition.
f. Ad. sk.	Falkland Islands.	J. Gould, Esq.
g. [illegible]	Santiago, Chili.	Herr Landbeck [C.].
h. Ad. sk.	Straits of Magellan (*Capt. King*).	The Admiralty [P.].

5. Cistothorus polyglottus. Cat. 96 Nr. 5

Todo voz, *Azara, Apunt.* ii. p. 29; *Hartl. Ind. Azara*, p. 10.
Thryothorus polyglottus, *Vieill. N. Dict. d'Hist. Nat.* xxxiv. p. 59 (ex *Azara*); *Bp. Consp.* i. p. 221; *Burm. Th. Bras.* ii. p. 136.
Troglodytes [illegible], *Licht. in Mus. Berol.*; *Naum. Vög. Deutschl.* iii. table to p. 724.
Troglodytes interscapularis, *Von Nordm. in Erman's Reis.* p. 90, *Atlas*, pl. 13; *Licht. Nomencl. Av. Berol.* p. 34; *Gray, Hand-l. B.* i. p. 180, no. 2604.
Troglodytes polyglottus, *Gray, Gen. B.* i. p. 158; *id. Hand-l. B.* i. p. 180, no. 2606.
Cistothorus interscapularis, *Cab. Mus. Hein.* Th. i. p. 78, note.
Cistothorus interscapularis, *Burm. Th. Bras.* ii. p. 136; *Pelz. Orn. Bras.* p. 414.
Cistothorus elegans, *Scl. & Salv. Ibis*, 1859, p. 28; *Scl. Cat. Amer. B.* p. 30; *Baird, Review Amer. B.* p. 148; *Salv. P. Z. S.* 1870, p. 182; *Scl. & Salv. Nomencl. Av. Neotr.* p. 7; *Baird, Brewer, & Ridgw. Hist. N. Amer. B.* i. p. 159; *Salv. & Godm. Biol. Centr.-Amer., Aves*, i. pl. vii. fig. 3.
Cistothorus polyglottus, *Pelz. Orn. Bras.* pp. 48, 414; *Scl. & Salv.*

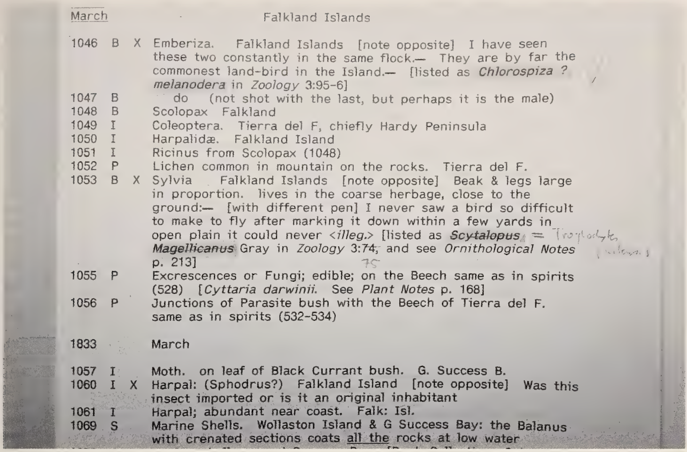
Figure 8. Manuscript annotations detailing additional specimens of *Cistothorus platensis,* opposite the printed list on Sharpe (1881), page 245 (© The Natural History Museum, London).

to the NHM collections after the publication of Sharpe (1881). One of these annotations reads: 'K. ad m. ? [? presumably for unknown locality]. Darwin. Godman [= Godman-Salvin Collection]' (Fig. 8). This refers to specimen NHM 1885.3.6.480, which indeed gives very little information on the attached label. However, on cross-referencing against Darwin's Red Notebook (which is in the Fitzwilliam Museum at Cambridge, and has long been known to contain collecting details about his specimens), there are actually good field data for this specimen: '1053 B X Sylvia Falkland Islands … lives in the coarse herbage, close to the ground …' (Fig. 9). Thus the bird can now be relabelled with the correct location and with additional ecological detail.

Eggs and texts: Popham and the Curlew Sandpiper, and eagle eggs

The impossibility of attaching a label to an egg means that clutch cards and diary entries are crucial to the maintenance of key data on egg collections. Labels placed in the box with the clutch (or clutches) are easily lost or misplaced. Usually a small clutch code written on the egg is the only way to link it to the clutch card and its data.

Hugh Popham (1864–1943) found the first authenticated nest-site of the Curlew Sandpiper *Calidris ferruginea* in 1897; these eggs and their clutch card are now in the NHM. His diaries were presented to the NHM in 1947, four years after the



March Falkland Islands

1046	B	X	Emberiza. Falkland Islands [note opposite] I have seen these two constantly in the same flock.— They are by far the commonest land-bird in the Island.— [listed as ***Chlorospiza ? melanodera*** in *Zoology* 3:95-6] /
1047	B		do (not shot with the last, but perhaps it is the male)
1048	B		Scolopax Falkland
1049	I		Coleoptera. Tierra del F, chiefly Hardy Peninsula
1050	I		Harpalidæ. Falkland Island
1051	I		Ricinus from Scolopax (1048)
1052	P		Lichen common in mountain on the rocks. Tierra del F.
1053	B	X	Sylvia Falkland Islands [note opposite] Beak & legs large in proportion. lives in the coarse herbage, close to the ground:— [with different pen] I never saw a bird so difficult to make to fly after marking it down within a few yards in open plain it could never <*illeg.*> [listed as ~~***Scytalopus***~~ = Troglodytes ~~***Magellicanus***~~ [illegible] Gray in *Zoology* 3:~~74~~ 75; and see *Ornithological Notes* p. 213]
1055	P		Excrescences or Fungi; edible; on the Beech same as in spirits (528) [*Cyttaria darwinii.* See *Plant Notes* p. 168]
1056	P		Junctions of Parasite bush with the Beech of Tierra del F. same as in spirits (532-534)
1833			March
1057	I		Moth. on leaf of Black Currant bush. G. Success B.
1060	I	X	Harpal: (Sphodrus?) Falkland Island [note opposite] Was this insect imported or is it an original inhabitant
1061	I		Harpal; abundant near coast. Falk: Isl.
1069	S		Marine Shells. Wollaston Island & G Success Bay: the Balanus with crenated sections coats all the rocks at low water

Figure 9. Page from the printed version of Darwin's Red Notebook, which includes information on 'Sylvia, Falkland Islands' (= *Cistothorus platensis*) which does not exist on the specimen's label (© Fitzwilliam Museum, Cambridge).

eggs[8]. The clutch card reads: '*Calidris ferruginea.* Korsakoffski Is. Yenesei R., Siberia. [Collector] H. L. Popham. 3 July 1897. [Set Mark] 387. [No. of eggs] c/4. Shot bird off nest, notebook vol.1, exhibited B.O.C. 20.10.97 [see Bull. B.O.C., 7 (1897): 2]; first authentic eggs on record' (Fig. 10).

The clutch card therefore includes information cross-referenced to one of Popham's original diaries, but these would not have been available to NHM staff when they first received the eggs. Popham's diary indeed has a long entry describing his discovery and collection of the contents of the Curlew Sandpiper nest, and also recounts how he collected the female parent. Of the eight Popham Curlew Sandpiper skins in the collections at Tring, three have their legs, with attached labels, detached. Popham's skinning technique obviously involved cutting the legs inside too low down the bone shaft, and not tying the bones together inside; thus the legs eventually fall out of the body. One of the three birds with detached legs is the female shot off the nest on 3 July 1897[9], but which one of the three skins belonged to which legs will now be impossible to say until genetic testing is more refined (and affordable). This situation underlines the importance of keeping legs—and thus labels—attached to birds, by repairing them, or in the immediate future by individually bagging each skin.

By the very nature of egg collections, where many have been illegally taken, data are encrypted, and clutch cards and diaries are often kept far away from the eggs to avoid prosecution, it is often worth waiting—often for years—for missing information to turn up. A clutch of White-tailed Sea Eagle *Haliaeetus albicilla* eggs, now at the National Museum of Scotland (Fig. 11), is labelled in ink as having been collected at Ardnamurchan on 7 May 1874 and were apparently without further data when the private collection they were in was confiscated by the RSPB[10]. The collector's diary[11] was given to the NMS by a completely separate source at a later date and gives a more detailed account of the collection of these two eggs (Fig. 12): '… Simon Ross took a nest situated on the cliffs overhanging the sea on the farm of Grigadale about 2 miles south of the lighthouse and Point of Ardnamurchan ….'.

Captive breeding records and studbooks: the first Budgerigar and Smalley's pigeons

The first Budgerigar *Melopsittacus undulatus* to be hatched in captivity in Britain was the subject of a letter in 1848 from the 13th Earl of Derby to John Gould. Gould had imported the parent 'Sparrow Parakeets' from Australia for Lord Derby, for his aviaries at Knowsley Hall, near Liverpool. In 1840 Gould had been the first person to import live budgerigars successfully from Australia to Britain. Lord Derby's letter to Gould (Fig. 13) recorded that:

> I have the pleasure to tell you we have been overjoyed here by the fact of a Pair of the *Melopsittacus undulatus* breeding. It was first observed by Thompsons

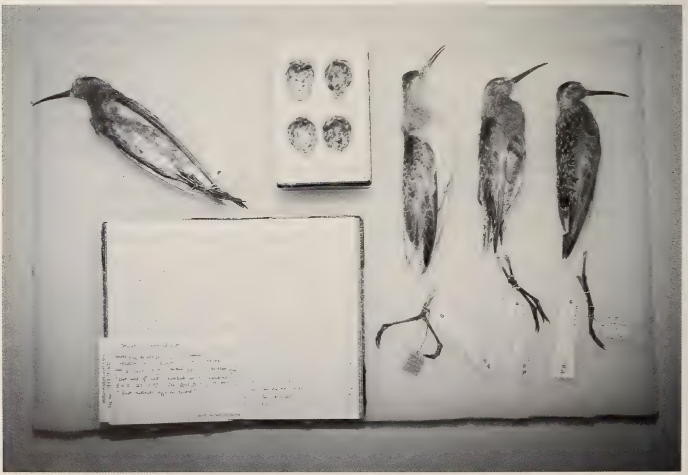


Figure 10. Popham's diary, open at the page where he recorded that he had shot a parent Curlew Sandpiper off its nest in Siberia on 3 July 1897. The picture also shows the eggs from this nest, the clutch card, and four Curlew Sandpiper skins collected by Popham (© The Natural History Museum, London).

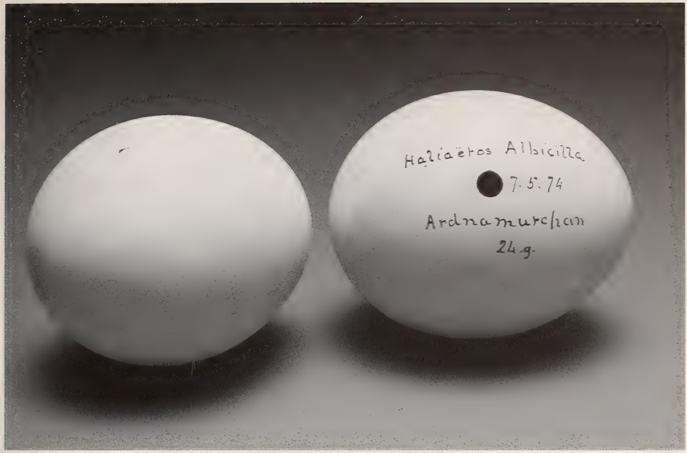
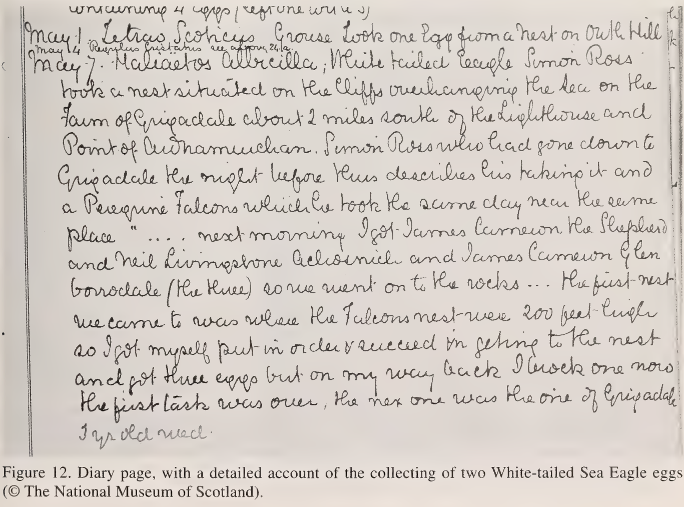
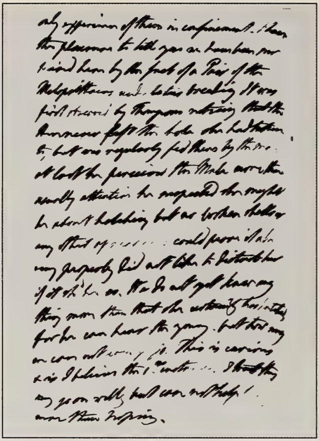


Figure 11. A clutch of two White-tailed Sea Eagle eggs, collected at Ardnamurchan in 1874 (© The National Museum of Scotland).



containing 4 eggs (before with 3)
May 1. Tetrao Scoticus Grouse took one Egg from a nest on Outh Hill
May 4 Regulus cristatus see above, 24.a.
May 7. Haliaetos albicilla; White tailed Eagle Simon Ross
took a nest situated on the Cliffs overhanging the sea on the
Farm of Grigadale about 2 miles south of the Lighthouse and
Point of Ardnamurchan. Simon Ross who had gone down to
Grigadale the night before thus describes his taking it and
a Peregrine Falcons which he took the same day near the same
place " . . . . next morning I got James Cameron the Shepherd
and Neil Livingstone Achosnich and James Cameron Glen
borrodale (the three) so we went on to the rocks . . . the first nest
we came to was where the Falcons nest were 200 feet high
so I got myself put in order & succeed in geting to the nest
and got three eggs but on my way back I brock one now
the first task was over, the nex one was the one of Grigadale
3 yr old nest.

Figure 12. Diary page, with a detailed account of the collecting of two White-tailed Sea Eagle eggs (© The National Museum of Scotland).



only experience of them in confinement. I have
the pleasure to tell you we have been now
paid here by the fact of a Pair of the
Melopsittacus undulatus breeding. It was
first observed by Thompson noticing that the
Hen never left the hole she had taken
to, but was regularly fed there by the ma-
-le at last he perceived the Male arouse the
unusually attention he suspected she might
be about hatching but as broken shells or
any other sign [illegible] could prove it. As he
very properly did not like to disturb her
if it sh'd be so. We do not yet know any
thing more than that she actually [illegible]
for he can hear the young - but how many
or even whether any [illegible]. This is curious
& is I believe the 1st instance [illegible]. I doubt they
any go on well, but can not help
more than hoping.

Figure 13. Extract from a letter from the 13th Earl of Derby to John Gould, dated 11 February 1848 and recording the hatching in captivity of Budgerigars, for the first time in Britain (© The Natural History Museum, London).

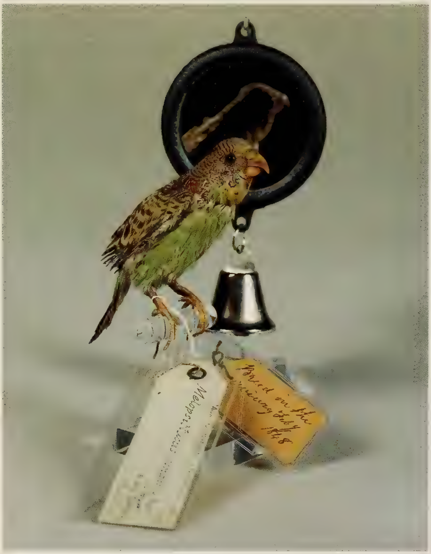


Figure 14. A Budgerigar chick, from the first pair to be hatched in captivity in Britain (at Knowsley Hall, in 1848) (© NMGM).

> noticing that the hen never left the hole she had taken to … we can hear the young …this is curious and I believe the 1st instance[12].

The two young birds unfortunately died soon after hatching, but one is preserved in the collections of the Liverpool Museum, complete with a label recording when it died[13] (Fig. 14).

Two manuscript volumes representing Smalley's pigeon studbook (1904) refer to domestic pigeon varieties represented by specimens now in the collections at the Natural History Museum, Tring, and give details of plumage and lineage which are not on their labels[14] (Fig. 15). Although it might not seem that storing information on captive birds is an important part of a museum's remit, such information is often sought by aviculturists and historians and is an inviting topic for the general public. The Liverpool Museum budgie, for instance, was by far the most popular and most photographed exhibit out of all the hundreds of specimens and works of art in a recent exhibition about the 13th Earl of Derby.

Incidental biographical material

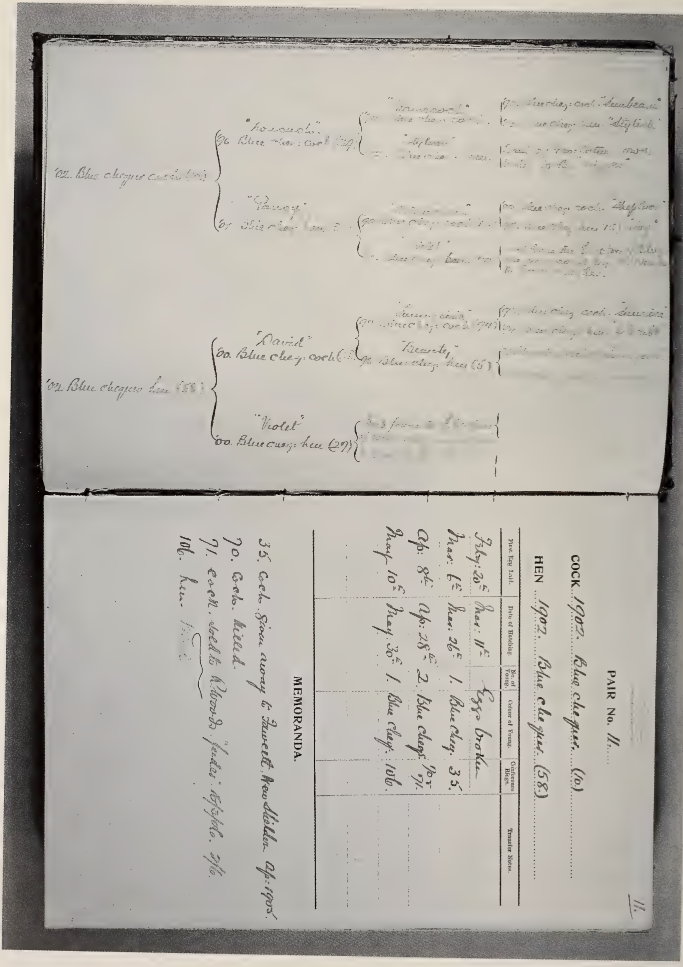
An incidental part of working with paper is the occasional fleeting insight it may grant into personal circumstance and social history. Manuscript bird labels are often recycled backs of calling cards, entrance tickets or invitations. Many of John Gould's specimens, for instance, are labelled on the back of strips cut from the entrance tickets to his 1851 Hummingbird exhibition at Crystal Palace in London. This also can be useful in dating his specimens. Figure 16 shows a Royal Society invitation to Burlington House for the eminent ornithologist Canon Tristram 'and a Lady'. This invitation was reconstructed from the reverse side of bird skins labels in the National Museum of Scotland (Fig. 16).

Figurative material

Illustration, first by drawing and more recently also by photograph, has been a crucial means of conveying information about species and indeed their habitats. However, in much the same way that specimen material is often simply archived in a museum collection without being published (see Collar & Rudyanto 2003, this issue), so it is with figurative material, and with the same result—that there is often a great deal of important information to be discovered through the examination of these types of record.

Illustrations of extinct species, 1: the Pink-headed Duck

The Impey Collection (1774–1783) contains exquisite gouache paintings, of which about 120 are thought to survive, executed by artists trained in the Moghul tradition. They are mainly portraits of birds which lived in captivity in the gardens created in Calcutta by Lady Impey and her Chief Justice husband, Sir Elijah Impey. Many of these paintings were the first known records of particular species of bird and, after



11.

PAIR No. 11.

COCK 1902. Blue chequer. (10)

HEN 1902. Blue chequer. (58.)

First Egg Laid.	Date of Hatching.	No. of Young.	Colour of Young.	Conference Rings.	Transfer Notes.
Feby: 20th	Mar: 11th		Eggs broken		
Mar: 6th	Mar: 26th	1.	Blue cheq.	35.	
Ap: 8th	Ap: 28th	2.	Blue cheqs.	70 & 71.	
May 10th	May 30th	1.	Blue cheq.	106.	

MEMORANDA.

35. Cock. given away to Fawcett. New Shields Ap: 1905.
70. Cock. killed.
71. cock. sold to R. Woods. "feeder" 15/3/06. 2/6.
106. hen.

Figure 15. A page from Smalley's Pigeon Studbook, showing details of hatching and lineage (© The Natural History Museum, London).

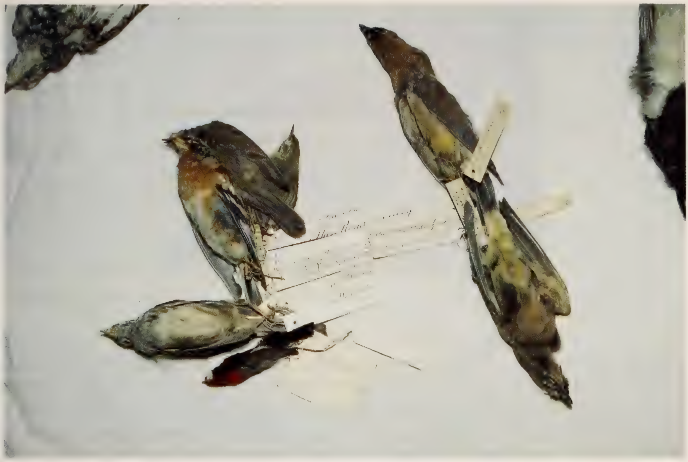


Figure 16. Invitation from the Royal Society to Canon H. B. Tristram, reconstructed from the backs of bird labels at the National Museum of Scotland (© The National Museum of Scotland).

the Impeys had returned to Britain with their pictures, were used extensively by the distinguished English ornithologist John Latham to describe forms new to science.

Two of these 'iconotypes', both by Shaikh Zayn-al-Din, are described below, and were from a group of four Impey paintings recently purchased by NMGM (Fisher 1999)[15]. Another fine painting from this group is by the Moslem artist Ram Das. It was purchased on the grounds that it is probably the earliest known portrait of the Pink-headed Duck *Rhodonessa caryophyllacea* (Latham). This duck has not been seen since the 1940s and is probably, but not certainly, extinct (BirdLife International 2001). Latham (1787, supplement 1: 276) stated that the duck 'Inhabits various parts of India … [and] Is often kept tame ..'. The painting by Ram Das was almost certainly painted using a living model, and as such this composition is of great interest and importance (see Fisher & Kear 2002).

Illustrations of extinct species, 2: Lieutenant Robins's Macaw

A spectacular and interesting painting (Fig. 17) by a Lt. L. J. Robins has recently been discovered in a private collection, in a bound volume of works dated 1765[16]. The volume is entitled *The natural history of Jamaica,* but the bird does not match very well with the description of the only known specimen—shot near Lucea in 1765 (Gosse 1847)—of the Jamaican (or Yellow-headed) Macaw *Ara gossei*, a species which is sadly no longer extant. In Joseph Smit's plate in *Extinct birds* (1907), which

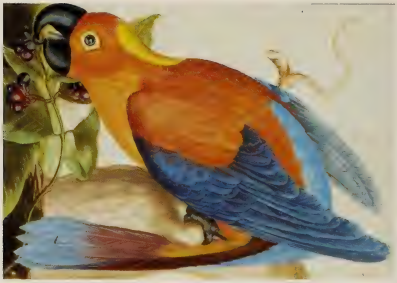


Figure 17. Macaw, from a volume of paintings entitled *The natural history of Jamaica* by L. J. Robins (© The Earl of Derby).

accompanies Walter Rothschild's quotation of Gosse's account of the Jamaican Macaw (and from which Rothschild took his 1905 type description), the bird clearly has a yellow crown, whereas Robins's Macaw seems only to have a yellow crest; nor does Robins's Macaw seem to match the plumage of the now-extinct Cuban Macaw *Ara tricolor*.

Illustrations of extinct species, 3: the Great Auk

This species, which became extinct in the 1840s, is known from mounted specimens, eggs and osteological material. However, much of its ecology and behaviour, as well as the story behind the bird's extinction, has been deduced from written accounts

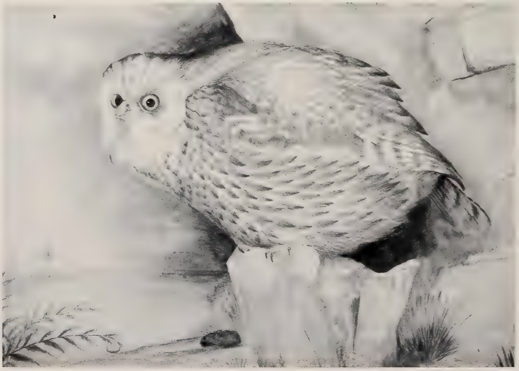


Figure 18. Painting of a New Zealand Laughing Owl, by an unknown artist, from the Rothschild Library at Tring (© The Natural History Museum, London).

and from old pictures. One such old drawing is an engraving (see Fuller 1999: 65) from Newfoundland by F. W. Keyl and E. Evans, produced in about 1880, which gives a very strong impression of the hunting techniques used for the mass dispatching of the flightless bird.

However, probably the earliest drawing of the Great Auk known is one that not only proves that the bird occurred on the Isle of Man but also suggests that it bred there. The drawing (reproduced in Williamson 1939, Fisher 1997, Fuller 1999: 367) is by Daniel King and dated about 1652. It is captioned 'These kind of birds are about the Isle of Man', and shows a Great Auk standing on a flat rock, which were their usual breeding sites. Other contemporary accounts record the species on the Isle of Man, and some pieces of bone excavated at two archaeological sites on the island—Perwick (Garrad 1972) and Castletown (Fisher 1996)—have confirmed its presence there.

Illustrations of extinct species, 4: the New Zealand Laughing Owl

The Laughing Owl *Sceloglaux albifacies* was first named by George Gray in 1844 from a specimen from the voyages of the ships *Erebus* and *Terror*. He was struck with the white face of the specimen, hence *albifacies* (= 'white-faced'). Later, specimens with rufous faces (which may be colour morphs) were collected.

This species has been extinct since 1914, and is only known from about 30 specimens. Only two paintings of the bird exist which appear to be done from life: one by J. G. Keulemans in Rowley's *Ornithological miscellany* (1875, vol 1: opp. p.35), painted from Rowley's own captive specimens, and a painting now in the Rothschild Library at Tring, which was done by an unknown artist. The few other pictures of the Laughing Owl show it upright, but in this last painting it has a sideways, hunched stance (Fig. 18). The painted tail has been much changed, from thick to thin. Rothschild had this picture up on his wall in his museum at Tring for many

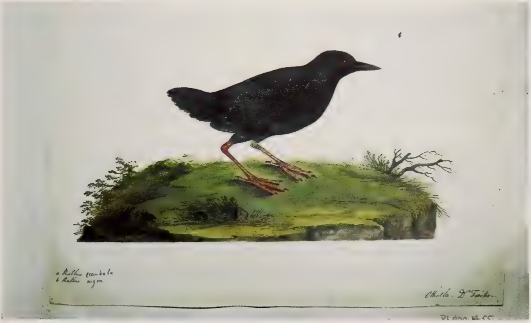


Figure 19. *Rallus nigra* from "Otheila" (= Tahiti), by George Forster (© The Earl of Derby).

years, so he obviously thought it was special. It may have been of the live specimen he had in confinement in Cambridge, in which case the painting was probably done from life. This Cambridge bird is now in the collections of the NHM at Tring.

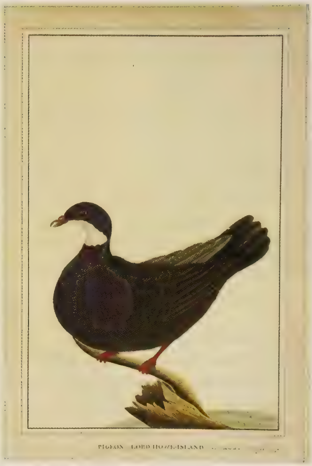


Figure 20. Lord Howe Island Pigeon, by George Raper (1790), from the Raper Drawings at the Natural History Museum (© The Natural History Museum, London).

Illustrations of unknown species, 1: the Tahiti Black Rail

An original watercolour (now in private hands[17]) of a rail named *Rallus nigra* was published in 1784 in *Icones animalium* by the artist John Miller, but without locality. It was therefore supposed to be either a picture of the Henderson Island Rail *Porzana atra* ('*Nesophylax ater*'; as synonomised in Peters 1934, 2: 188), or an earlier version of George Forster's picture of *Porzana tabuensis* (which is from Tahiti and neighbouring islands). Thus it was recommended that the name *Rallus nigra* be suppressed. However, the original watercolour is clearly marked 'Otheila (= Tahiti). Dr Forster' (Fig. 19) and the bird does not look like *Porzana tabuensis*. Michael Walters of NHM (who has been analysing this picture) thinks that *Rallus nigra* was probably more closely related to *P. atra* but was a distinct species that once lived on Tahiti. It would be useful to discover some fossils to prove this theory.

Illustrations of unknown species, 2: the Lord Howe Island Pigeon

There are only two known portraits of the Lord Howe Island Pigeon *Janthoenas godmani*. One is amongst the collection of George Raper's drawings in the NHM[18] and is dated 1790. The other (which is almost identical and is probably a copy of Raper's picture, although the bird is sitting on the ground rather than perched on a branch) is amongst an important collection of paintings[19] produced by an unknown artist in about 1790. This latter picture is reproduced in Hindwood (1940, plate 1). The Raper picture was used by Gregory Mathews to name the species in 1915, and copied by Henrik Grönvold for Mathews's *Birds of Norfolk and Lord Howe Island* (1928) (Fig. 20).

Illustrations that involve taxonomic types

Of the four Impey paintings recently purchased by NMGM (see above), two—both by Shaikh Zayn-al-Din—are almost certainly types (pictures, rather than specimens, to which the author was referring when writing the type description of a new species). The first is entitled 'Bhu'khur' (= 'Cuckoo')[20] and was painted in 1782. This shows the Little or Asian Lesser Cuckoo *Cuculus poliocephalus*, which was given this scientific name by Latham (1790, I: 214). Latham stated that he founded his scientific name on the 'Grey-headed C[uckoo]' of his *General synopsis of birds* (1787, Supplement I: 102), where he reported that his description was based on a bird in one of Lady Impey's collection of drawings. This must be the drawing he was referring to. Shaikh Zayn-al-Din's painting therefore has type status for the name *Cuculus poliocephalus*.

Another of the four Impey paintings recently purchased by NMGM is a delightful portrait of a 'Syam Chakar' ('Siam Nuthatch') on what appears to be a cinnamon tree (Fig. 21)[21]. We are fairly sure that this portrait is the basis of Latham's name *Sitta longirostra* (1790: 264; the 'Long-billed Nuthatch' from 'Batavia'), which Peters (1967: 142 footnote) reported to be 'not identifiable'. James Greenaway, who wrote this footnote, did not have the luxury of seeing Shaikh Zayn-al-Din's portrait of the bird, which was in private hands at the time, nor had he traced Latham's latinised description back to the *General synopsis of birds* (Supplement Part I: 118, 1787) or to *A general history of birds* (4: 73). In both these accounts Latham states that he was describing his Long-billed Nuthatch 'From the drawings of Lady Impey'. The plural 'drawings' is interesting; it could be construed that there was more than one of this nuthatch. Indeed, the Impey 'Syam Chakar' at NMGM is actually more probably a syntype, because several of the Impey drawings seem to be duplicates of the same species, and Latham is likely to have had access to all the paintings, including the duplicates.

A very similar painting of a nuthatch is in a bound volume of original paintings in the Rothschild Library at the NHM, Tring, entitled *Indian birds colourd*[22]. For a long time the artist, or artists, responsible for the illustrations in this volume remained unidentified. In recent years a Farsi-speaking visitor translated some signatures as 'Sheikh Ed-dine'. On comparing the two nuthatch paintings, it was confirmed that the Tring picture was another original by Shaikh Zayn-al-Din (Fig. 22). The only real difference is the way the cinnamon plant on which the bird is perched has been painted. The two pictures are therefore now regarded as syntypes for Latham's name *Sitta longirostra*. However, there still remains the puzzle of which species *Sitta longirostris* actually is equivalent to in modern terms. The fact that 'Syam Chakar' is written on the NMGM version hints that *S. longirostris* could be a Siamese (Thai) species.

Photographs of birds: the New Zealand Laughing Owl and the last Heath Hen

Only a few photographs were ever taken of the now-extinct New Zealand Laughing Owl; two reproduced in *Tyto* 3 (1998: 17-18) were taken in about 1909 by Cuthbert

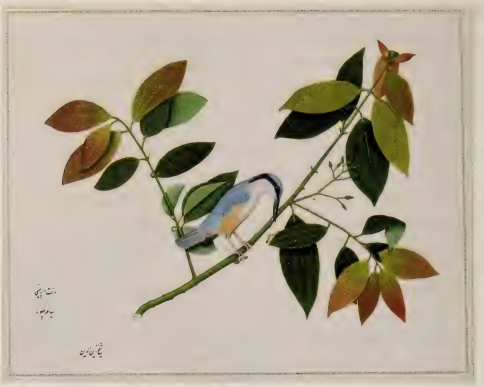


Figure 21. "Syam Chakar" (Siam Nuthatch), painting by Shaikh Zayn-al-Din, recently purchased by Liverpool Museum, NMGM (© NMGM).

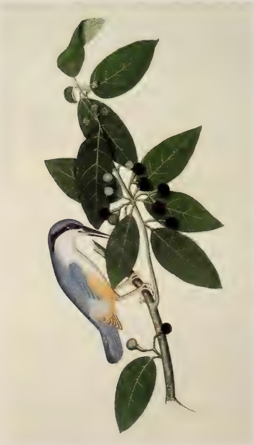


Figure 22. Painting of a nuthatch, by Shaikh Zayn-al-Din, from a bound volume entitled *Indian birds colourd* in the library at Tring (© The Natural History Museum, London).

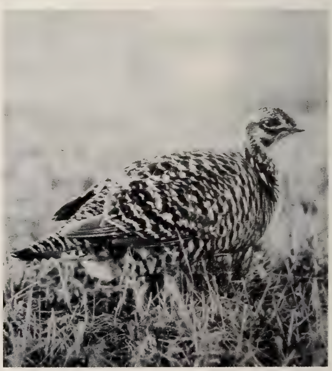


Figure 23. Previously unpublished photograph of a Heath Hen, taken by Alfred O. Gross at Martha's Vineyard on 31 March 1930 (© The Natural History Museum, London). Registration number 654-J-22).

and Oliver Parr. Both show an owl in a small rocky shelter, with a mouse in its beak. The only other photograph is one by Henry Wright of a captive bird, probably one of the pair shipped to Rothschild by Walter Buller in 1892 (this is also mentioned in *Tyto* 3). These photographs are very useful historical records in themselves, but are also valuable in relation to the pose and shape of the Laughing owl in the painting at Tring (see above).

Five excellent photographs were taken of living Heath Hens *Tympanuchus cupido* at Martha's Vineyard, Massachusetts, by Alfred O. Gross in 1929 and 1930, just before the species became extinct. One of these photographs is reproduced in W. T. Hornaday's book *Thirty years war for wildlife* (1931). The rest remain, so far as we are aware, unpublished; prints are in the Ornithology Library at Tring (Fig. 23).

Discussion and conclusions

The examples above indicate the various ways in which material on paper, stored in museums, can serve science well if it is only recognised for its potential value and put to good use. We say 'stored in museums' but the title of our essay acknowledges that with this material there is a great deal of interplay between museums and libraries. Often the libraries are part of the museum (most large collections of birds have their own dedicated library), but sometimes they are, as it were, equal members of a wider institution. Thus, for example, we now have available the notes of H. H. Slater (c.1875) on the birds of Rodrigues, which came to Alfred Newton via his brother Edward as part of a consignment of material sent to the Cambridge University Museum of Zoology. These were tracked down and used by Cheke (1987), but are now in the Newton/Balfour Library in the Department of Zoology at the University of Cambridge and no longer therefore a document preserved in the museum itself. The movement of scripts and illustrations from museum to library is doubtless a common one, and future workers should be aware that events of ostensibly trivial significance at the time (such as the sale or disposal of papers, or the administrative restructuring of faculties and departments) can dissociate documentation from its subject material in such a way as to require considerable extra diligence and scholarship on the part of future interested parties.

The examples we have used in this essay are perhaps rather dramatic and extreme, since for the most part they deal with the very rarest species, or species that are now lost to us. We should also stress that field notebooks, diaries, letters (and so on) can be extremely valuable sources of information about the status of what were, in centuries past, common birds. These manuscripts can, of course, also tell us a great deal about the status of the habitats these birds then occupied. Indeed, their value may become increasingly obvious as biologists and conservationists investigate declines of species that were once so common that their detailed documentation was considered unimportant, with the result that their former status has perhaps only very generally been described in the published literature. If museum archives hold documentation that can more precisely account for the former status of a species, then in due course they are likely to become more and more valuable to researchers.

There are, however, very considerable drawbacks with regard to the status of paper holdings in museums. Two key ones are that (1) most of the material is very little known to museum users and indeed museum staff, and (2) most of it is inadequately indexed for ease of reference; moreover, although this is a separate and less ubiquitous problem, (3) it is often either unavailable, or available in only constrained physical and/or temporal circumstances (thus, for example, A. S. Cheke [verbally 1999] found that, in the 1970s, the correspondence of Alfred Newton—Professor of Zoology at Cambridge University and dead since 1907—was not open for consultation because it was uncatalogued; this embargo lasted until the mid-1990s when the material was transferred to the University Library). We might also add (4) that there are fewer and fewer biologists at present who have the necessary training and *type* of scholarly outlook and interest to make valuable use of paper holdings. In the past, much of this expertise was handed down by day-to-day example, difficult to maintain in these modern times of staff shortages and alternative duties.

As a consequence, museum users are unlikely to make routine reference to such material. Certainly it is the case that a researcher needs to be extremely focused, or obsessed, in order to work through a body of paper holdings in search of particular items of information or pieces of evidence. Nevertheless, there is much that museums can do to improve the situation—by providing more details in a more public manner about their paper holdings (through exhibitions, catalogues, scientific papers, websites), by liaising with other academic institutions and inviting debate about the scholarly study of their materials, and by setting up programmes of cataloguing, indexing and description of holdings. All of this might cost money, but not necessarily great sums, and some of the work could be entrusted to volunteers. We would, at any rate, be inclined to feel that the long-term security of much of the paper-based material in museums would be enhanced by greater clarity and assertiveness over its value as a relevant contemporary research resource in history and biology.

Acknowledgements

We would like to thank the following ornithologists and librarians for their suggestions and help with examples included in this paper: the Javan Lapwing—Nigel Collar, Rene Dekker and Jörn Scharlemann; the São Tomé Short-tail—Nigel Collar; the Giant Chatham Island Rail—Joanne Cooper; the Tahiti Black Rail—Amanda Askari and Michael Walters; the Great Auk—Errol Fuller; Sharpe's *Catalogue* and Darwin—Frank Steinheimer; Popham's diary—Michael Walters and Jörn Scharlemann; the White-tailed Sea-eagle eggs and for Canon Tristram's invitation—Bob McGowan.

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Footnotes

[1] Paradise Parrot letter, see draft and formal letter from Gould to Gilbert, in National Library of Australia, Canberra.

[2] Copy by Lord Derby of Gilbert's letter: LCL 920 DER (13) 1/67/11.

[3] Both are now in the collections of the Liverpool Museum, NMGM.

[4] LIVCM D.789a.

[5] Gilbert's diary in the Mitchell Library is in two parts, one of which is mislaid and at present only available as a typescript copy. Original volume: ML A2586, typescript ML A2587.

[6] 'Great Auk – Miscellaneous Papers', compiled by H. Barclay and later T. Parkin. NHM (Tring Library).

[7] NHM, Tring; the working copy of Sharpe's Catalogue of birds in the BMNH is kept outside the curators' offices on the first floor of the bird collection building.

[8] Eggs: Popham Collection 1943.7.471. H. L. Popham's journals (Travel Diaries in 7 volumes) are kept in the Library at NHM Tring.

[9] Female Curlew Sandpiper skin, NHM 1938.12.14.91 (collected July 3rd 1897, from the Yenisei River, Popham's collection number 500 [387]).

[10] White-tailed Sea Eagle eggs: NMSZ 1991.111.

[11] Diary in J. J. Dalgleish collection, National Museum of Scotland.

[12] John Gould Archive, Zoology Library, Natural History Museum, London.

[13] LIVCM D.505g, died in the Knowsley aviaries in February 1848.

[14] Smalley's Pigeon Studbook in 2 volumes, 1903-1913. NHM, Tring Library.

[15] Impey Collection LIVCM 1999.36.2-5. These were once in the possession of the XIIIth Earl of Derby, at Knowsley Hall. The Pink-headed Duck is numbered 1999.36.4.

[16] Robins's 'The Natural History of Jamaica' in seven volumes, Knowsley Hall Library, NH11 E13-19.

[17] Knowsley Hall Library, near Liverpool. Painting by John Miller but pasted on page 12 of a bound volume of paintings mainly by Thomas Davies, NH14 E9.

[18] Raper Drawing No.72, Zoology Library, NHM South Kensington. George Raper was a midshipman on the *Sirius*.

[19] Painting no. 41 in a collection of original pictures in the Alexander Turnbull Library, Wellington, New Zealand

[20] NMGM 1999.36.2.

[21] NMGM 1999.36.5. It must have been painted between 1774 and 1783, the period the Impeys were in India.

[22] '*Indian Birds Colourd*', plate 40, NHM Tring Library.

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Egg and skin collections as a resource for long-term ecological studies

by Rhys E. Green & Jörn P. W. Scharlemann

Summary

Well labelled and reliable series of bird skins and eggs collected over long time-spans offer opportunities to determine environmentally induced changes in parameters of ecological interest, such as geographical range, the age structure of populations, clutch-size, and the timing of breeding and migration. They also reveal environmentally induced changes in morphology related to pollution and a changing food base. Finally, they can be used for various chemical analyses to determine the presence and effects of certain environmental pollutants and even, through stable isotopes, the geographic origins of particular birds and changes in their diets over time. The value of museum collections for these purposes is sufficiently high for us to recommend the resumption of the systematic accumulation of avian specimens for long-term ecological research, but this should only be done if adverse effects on conservation status can be avoided. One example is the long-term scheme to collect specimens of birds of prey found dead by the public in the U.K., which has resulted in several valuable conservation-oriented applications.

Introduction

Museum collections have been used most frequently for research on taxonomy, phylogeny and geographical distribution. However, avian museum collections contain much information relevant to other areas of biological research, such as ecology, behaviour and physiology (Ricklefs 1980). Of particular interest to ecologists are the long series of specimens collected over 100–200 year spans which offer opportunities to study long-term changes in morphology, phenology and chemical composition, and in this paper we focus on the use of avian museum collections for such long-term ecological studies.

Avian specimens are preserved in museum collections as skins, skeletons and as whole specimens in alcohol or formalin, eggs and nests. Of these, usually only skins and eggs are collected in large enough numbers to give sufficient material for ecological long-term studies which require large data series. Natural history museums, with their commitment to long-term preservation and documentation of specimens, provide an excellent resource for ecologists. The value of a long-term ecological study is difficult to predict in advance, so relatively few continue for decades. Museum collections are a resource for retrospective long-term studies and especially for monitoring and hypothesis testing.

We identify three ways in which ornithological collections can provide information for long-term ecological studies. These are: the use of data from labels; morphological measurements; and chemical analysis. We present examples of each of these types of research and indicate technical difficulties and prospects for progress.

Distribution, life history and phenology from collection label data

The data held on a specimen usually include information on species, collecting date and approximate locality. Sometimes there is also information on age, sex, moult, stage of development of gonads, skull ossification, clutch size, stage of development of embryos, habitat and precise locality (latitude/longitude or national grid reference). To obtain these data it may be necessary to examine the label attached to the specimen or to consult accompanying registers, notebooks, data-cards or computerised databases. Large amounts of data can be accumulated quickly. This information can be used for studies of distribution, life history and phenology.

Distribution

Data from egg and skin collections can make a valuable contribution to establishing the range of a bird species. The use of clutch and nest localities is preferable for establishing the breeding range if there is a possibility of migration or dispersal. Museum collections can reveal long-term changes in distribution, especially the contraction of range. Evidence from museum specimens for the expansion of range is likely to be less reliable because the earlier lack of specimens from an area might reflect lack of collecting effort. Contraction of range can be checked by new survey work.

Life-history studies

Some indication of long-term changes or geographical differences in the demographic rates of birds may be available from museum collections. Proportions of skins attributable to different age categories may reflect the balance of recruitment and mortality in the sampled population. Snow (1956) used the proportion of first years to adults in museum collections to estimate annual mortality rates of Blue Tits *Parus caeruleus* in different parts of Europe. The colouration (green or blue) of the wing-coverts allows one-year-old adults to be distinguished from older birds. Mortality rates varied among seasons and regions within Europe. However, for some species, the methods used to obtain specimens could influence the age distribution, so results should be interpreted with caution.

Clutch sizes from museum egg collections can be used to investigate changes over time. Rodgers (1990) showed that the clutch size of North American Wood Storks *Mycteria americana* had not significantly declined from 1875 to the late twentieth century. Therefore reduction in clutch size cannot account for the population decline observed in Florida. In contrast, the clutch size of the Snail Kite *Rostrhamus sociabilis* in the Florida Everglades decreased significantly over 100 years, during a period of change in hydrology (Beissinger 1986).

A problem with the use of records of clutch size from museum collections is that egg collectors were probably selective with respect to clutch size. Lack (1946) showed for the European Robin *Erithacus rubecula* that clutches in collections were 0.52 eggs larger compared to field observations. The distribution of clutch size was skewed towards larger clutches for data from oological collections (Lack 1946). Some egg collectors may have made up large false clutches to impress their fellow collectors, but it is thought that these can usually be identified (see for example Beissinger 1986).

Phenology

Phenology investigates the timing of naturally recurring events and the relationship of their timing with biotic and abiotic variables. Examples include arrival and departure dates of migratory birds and the timing of egg-laying (Sparks & Crick 1999). One hypothesis is that the observed and recorded event is correlated with climate.

Several recent field studies have shown that birds are laying eggs earlier in north temperate areas than in the past (Crick *et al.* 1997) and that egg-laying dates are correlated with spring temperature (McCleery & Perrins 1998, Crick & Sparks 1999) and the North Atlantic Oscillation (Forchhammer *et al.* 1998). Most of these studies are based on data from nest record cards from the British Trust for Ornithology, which are available for only the last 30–50 years. Egg collections on the other hand provide longer-term data, going back over 150 years. The oldest dated specimen in the egg collection of the Natural History Museum, Tring, is a Great Bustard *Otis tarda* from 1801 (N. J. Collar pers. comm.; see also Walters 1993), but large numbers of specimens are available from 1850 onwards. Dates of collection of clutches can easily be recorded from labels and long-term changes and relationships with climate investigated. Egg-laying dates can be estimated if a record was made of the stage of development of the embryos (McNair 1987), but this information was often not recorded. Another problem is that the terminology used to describe development is variable and specific to the collector. Although eggs containing large embryos often have a large hole through which the egg contents were removed, the diameter of this hole is not always a good indicator of incubation stage (Storer 1930; see McNair 1987).

Rodgers (1990) used data from museum labels from North American Wood Stork eggs collected in Florida to study geographic and temporal variation in laying dates. He showed that there is a significant north–south difference in the main period of egg-laying. Storks in southern Florida lay eggs in October and December to June, whereas birds in central Florida lay between February and May. Laying dates in southern Florida changed from being concentrated in one month (January) in the nineteenth century to a wide spread of laying months observed in the twentieth century. It was suggested that this change might be caused by changes in the hydrology of southern Florida.

Byrkjedal & Thompson (1998) used the results of an extensive compilation of the dates and distribution of localities where museum skins of tundra-breeding plovers *Pluvialis* were collected to describe the phenology of long-distance migration. This approach is widely applicable to comparative studies of the timing of migration and could be used to study changes in migration over time.

Problems with label data

Caution has to be taken when using data from labels. In addition to the problems already mentioned, there is the possibility of accidental or deliberate inaccuracy. Eggs may be especially likely to be associated with falsified data in countries where egg collecting has been illegal in recent decades, because collectors fear prosecution and therefore may falsify collection dates (review of legal aspects in Sutcliffe 1993).

Morphological measurements

Museum specimens represent an immense resource of morphological data for comparative studies among regions and over long periods of time. The length and breadth of eggs and the weight of the shell are commonly recorded for eggs in museum collections. Other possible measurements include blowhole diameter, which is useful for adjustment of shell weight for the missing piece of shell in calculation of eggshell indices. Multiple measurements or photogrammetry can be used to measure egg shape, and eggshell thickness can be measured directly using a modified micrometer (see Green 1998). A variety of measurements of the bill, legs, wings and feathers can be taken from skins.

Long-term changes in eggs associated with environmental pollution

The detection of eggshell thinning as an effect of contamination of birds of prey with DDE (a metabolite of the insecticide DDT) relied heavily on the use of eggs in museum collections (Newton 1979). The most frequently used method is to weigh the eggshell and divide the weight by an index of the surface area of the egg calculated from the length and breadth. By comparing recently taken eggs with older museum specimens Ratcliffe (1970) showed that eggshell thinning in Peregrine Falcons *Falco peregrinus* in Britain had begun at the same time as the first widespread use of DDT in 1947 as a stepwise change. The correlation between introduction of DDT and eggshell thinning was observed in several species of raptor and fish-eating bird in Britain (Table 5 in Ratcliffe 1970) and around the world (Anderson & Hickey 1972, Newton 1979, Risebrough 1986). The eggshell thickness of most species recovered, once organochlorine pesticide use had been reduced or phased out (Newton 1986, Risebrough 1986, Ratcliffe 1993).

A recent study by Green (1998) found that eggshell thickness of four species of thrush has declined over the past 150 years. This decline was evidently not caused by organochlorine pollution, because it began before the introduction of DDT and a step-like decline is not observed. One possible hypothesis is that acid deposition has caused a reduction in the availability of calcium and that this reduced the quality of eggshells laid by thrushes. Such a mechanism is suggested by short-term experimental work on Great Tits *Parus major* in the Netherlands (Graveland 1998).

The extent to which differences in the methods used to prepare and store eggs might contribute to differences in indices or direct measurements of eggshell thickness is still uncertain. The use by collectors of chemicals and different mechanical techniques to remove egg contents, the application of preservatives and the accumulation of dust might all affect the measurements. As with all museum material, the selection of eggs on the basis of size, shape or other characters might also lead to bias.

Evolutionary changes in morphology

The detection of small changes in morphology resulting from natural selection is rendered more feasible by the use of museum specimens because it extends the time period over which they can be measured. Smith *et al.* (1995) showed that the bill size of a Hawaiian honeycreeper, the Iiwi *Vestaria coccinea*, was different for museum specimens collected before 1902 than for live birds measured in the 1990s. The proportion of birds with the longest upper mandibles had declined, leading to a reduction in mean length. The Iiwi formerly used its decurved bill to take nectar from the long curved corollas of flowers of lobelioids, which have declined greatly in abundance; the birds now feed mainly from flowers that do not have long tubular corollas. Hence it may be that natural selection has caused the observed change in bill length. The possibility that the apparent change might be caused by post-mortem alterations in the bill morphology of the museum specimens was evaluated in several ways. Smith *et al.* (1995) showed that bill measurements of a related species did not change significantly and that, although post-mortem changes in bill shape occurred, they could not account for the observed change in upper mandible length.

Tornberg *et al.* (1999) measured a large sample of museum specimens of Northern Goshawk *Accipiter gentilis* from northern Finland to test the hypothesis that a long-term decline in the abundance of grouse, one of their most important prey types, would change the pattern of natural selection for body size. They suggested that males, which are the smaller sex, should experience increased selection for small size because grouse are at the upper end of the size range of their prey spectrum and smaller prey have become relatively more important as the grouse declined. Conversely, the much larger females should experience increased selection for large size because their main alternative prey, mountain hare *Lepus timidus*, is larger than grouse. Hence, males were predicted to become smaller and females larger during a period in which grouse populations and their importance in the diet of Goshawks were both declining. Both of these predictions were supported by a multivariate analysis of 14 skin and skeletal characters. The fact that measurements of the two sexes changed in opposite directions clearly (a) rules out spurious trends caused by post-mortem changes and (b) renders implausible the possibility that the size of full-grown birds might have changed in response to changes in prey availability at the nestling stage.

Fluctuating asymmetry of morphological characters

Small random differences between the right and left sides in characters that are approximately bilaterally symmetrical are referred to as fluctuating asymmetry (FA). Variation among individuals in the degree of FA has genetic and environmental components and may increase with decreasing genetic variability and deteriorating environmental conditions. Comparative studies of FA may allow changes over time in genetic variability and/or environmental stress to be monitored in populations. Measurements of FA in museum specimens can extend the period of such studies.

Lens *et al.* (1999) studied FA in the tarsus length of forest passerines living in fragments of cloud forest in Kenya. They compared FA of museum specimens collected in 1938–1948 with that of birds mist-netted in 1996–1998. FA increased substantially for five out of the six species studied in a small (50 ha) and recently disturbed forest fragment, but showed no marked change over time for the same species in a larger (220 ha), less disturbed fragment. Studies of this type could be used more widely to identify the occurrence of environmental stress caused by habitat loss or deterioration and the effects of loss of genetic diversity. Parallel studies of changes in genetic diversity by DNA analysis from museum specimens, like that of Groombridge *et al.* (2000), might be a valuable adjunct in disentangling the relative importance of environmental stress and genetic diversity.

Changes in feather growth rates from ptilochronology

Some feathers show transverse markings consisting of alternating light and dark bars. These bars represent daily increments in the length of the feather during growth (Grubb 1989) and can be used after growth has ceased to measure the rate of extension of the feather. The technique is called ptilochronology. Measurements of growth bars can be made on feathers on museum skins, and changes in feather growth rates can then be compared over long time periods or among regions. Since feather growth may be affected by nutrition and environmental factors, such studies are of potential value in assessing long-term changes in habitat quality.

Carlson (1998) measured growth bars on the rectrices of White-backed Woodpeckers *Dendrocopos leucotos* from northern Europe. The growth bars on the feathers of museum skins collected between 1832 and 1942 were significantly wider than those of birds captured in Sweden during 1990–1992. It was also found that the width of the growth bars of birds in the recent sample was positively correlated with the density of dead trees. Since dead wood provides food for woodpeckers it seems plausible that variation in growth-bar width reflects differences in nutritional status. The difference between the growth bars of museum specimens and the recently trapped birds might then suggest that habitat conditions were less favourable in Sweden in the 1990s than they had been in the past.

Measurements of growth bars on museum skins appear to have potential value in long-term studies. However, it may be important to account for age and sex differences in feather growth rates and for differences in the areas in which specimens were collected in different time periods. A further problem is that growth bars are often indistinct and difficult to measure. Measurement methods could be improved if the precise physical basis of the bars was better understood.

Problems with morphological measurements

Researchers should be aware of several problems with morphological measurements of museum specimens. Shrinkage of various parts of bird skins occurs and may lead to distortion of shape as well as changes in linear measurements. Experiments conducted by Väisänen (1969) indicated that measurements of eggs are unlikely to be much affected by storage in museum collections. However, egg preparation techniques might change over time, thin-shelled eggs could break selectively, or dust may accumulate on the specimens. More detailed investigations are required to evaluate these problems.

The specimens in museum collections do not necessarily represent a random sample. Egg collectors in particular are known to wish to include abnormally coloured eggs in their collections (Lack 1958). Such eggs might also be atypical in other respects. Changes in such biases over time might then lead to spurious trends in measured parameters. This might invalidate Fisher's (1937) conclusion that eggs of abundant species are more variable in size than those of uncommon species. However, this observation could also be explained by collecting habits, since collectors might select for diversity in abundant species and keep all specimens of rare species.

Chemical analysis

Chemical analyses of museum specimens allow the tracking of changes in pollutants and the determination of birds' movements and diets. Museum specimens are ideal for monitoring because long time series are available, acting as temporal controls (i.e. specimens collected before the introduction of the pollutant) and spatial controls (specimens from areas where the pollutant is absent). Most chemical analysis methods require samples, such as feathers or pieces of eggshell, to be taken from the museum specimens. However, recent advances in sampling techniques and analysis methods require smaller sample amounts, which will reduce the impact on specimens in museum collections and allow large-scale, long-term data collection. Sampling is becoming less destructive, and more chemical analyses can be done. These advances have opened up a new field of museum-based research.

Pollutants

Chemical analyses of avian specimens from museum collections have shed light on many environmental problems. Birds accumulate heavy metals from their food and secrete them into their growing feathers during moult. Measurement of heavy metal concentrations in feather samples from live-trapped birds and museum specimens offers a method for monitoring long-term changes and spatial variation in contamination. Studies of mercury concentrations in seabird feathers provide an example of this approach. The concentration of mercury in feathers is related to that in the diet (Furness 1993). The mercury is stably bound to the feather keratin in organic form (Applequist *et al.* 1984). The presence of inorganic mercury added by post-mortem treatment of museum skins with inorganic mercury compounds as preservatives can be evaluated and allowed for by analysing total mercury and organic mercury concentrations separately (Monteiro & Furness 1997).

Analysis of contour feathers taken from live and museum specimens of four species of seabirds from the north-east subtropical Atlantic Ocean revealed substantial increases in mercury concentration over a period of more than 100 years (Monteiro & Furness 1997). The rates of increase observed were in accord with those predicted from knowledge of anthropogenic emissions of mercury. A potential complication is that species of fish and marine invertebrates vary considerably in their mercury concentration (Monteiro *et al.* 1998). Therefore, a change in diet could lead to a change in the mercury concentration in feathers that might be misinterpreted as reflecting a change in mercury contamination of the ecosystem.

The chemical analysis of pollutants in eggshell membranes was instrumental in establishing the association between the widespread use of DDT and eggshell thinning in raptors. Peakall (1974) used ether extraction to remove DDE residues from the inner eggshell membrane without destroying the specimens. Eggs collected before 1947 did not contain any DDT, whereas later eggs had high levels of DDT in their membranes.

More recent work has investigated the heavy metal concentration in eggshells directly. Flores & Martins (1997) compared metals in eggs laid near coal-based power plants to eggs laid 100 km away. Using graphite furnace atomic absorption spectrometry they determined cadmium, lead and fluoride concentrations in the eggshell and egg contents. The eggshells from polluted areas contained higher concentrations of cadmium, lead and fluoride. The development of these methods, combined with a newly developed laser ablation sampling technique, which requires only minute samples (about 50μm diameter), will facilitate large-scale sampling from egg collections and might help to evaluate the effects of pollutants on breeding birds and retrospectively assess long-term changes.

Tracing bird movements using stable isotopes

Most elements that occur in biological materials are found as at least two stable isotopes (Hoefs 1980 in Schaffner & Swart 1991). Isotope ratios vary geographically because of differences in geochemistry and various fractionation mechanisms during element cycling. These differences are reflected in the tissues of animals. The differences in isotope ratios in tissue can be used as natural ecological tracers, providing information on the regional origins and movements of individuals. However, isotope ratios, unlike ringing recoveries, cannot give very precise locations. The stable isotope ratios in an animal's tissues are correlated with the ratios in its diet. Elements commonly used are carbon, nitrogen, hydrogen, oxygen and strontium taken up through the food web. Tissues available for sampling from museum specimens of birds include bone, eggshell and feathers. Requirements for the size of samples are becoming small.

Chamberlain *et al.* (1997) and Hobson & Wassenaar (1997) found that stable isotope analysis of tissue from North American insectivorous songbirds could provide information on their breeding or natal locations. Hobson & Wassenaar found that a gradient in the relative abundance of deuterium in rainfall during the plant-growing season across North America was reflected in the deuterium content of feathers grown by birds at various sites. Hence, analysis of the deuterium content of feather samples taken from birds trapped on migration or in their winter quarters could be used to identify their origins. Chamberlain *et al.* (1997) similarly reported that gradients in deuterium and ^{13}C could be used to identify the probable region of origin of migratory warblers. They also found that bone samples varied in ^{87}Sr content, reflecting geographic variation in the abundance of this isotope among drainage basins with different underlying rocks. Their results suggest that using the relative abundances of several isotopes in a multivariate approach is likely to improve the precision with which areas of origin can be located.

An important issue for the application of stable isotope methods to museum specimens is the stability with which the element being studied is bound within the tissue being sampled. A fraction of the hydrogen and deuterium in feathers can exchange with the environment and so could be influenced by storage conditions. Chamberlain *et al.* (1997) found that 13% of the hydrogen in songbird feathers exchanged with that in the environment. Equilibration of feather samples with ambient water with a known standard relative deuterium abundance allows this potential problem to be overcome.

Monitoring changes and spatial differences in diet using stable isotopes

Stable isotope ratios in the tissues of animals are affected by the habitats they use for feeding. For example the relative abundance of ^{18}O in water and aquatic animals differs between freshwater and oceanic systems. Using the isotope signatures of eggshells, Schaffner & Swart (1991) showed that Western Grebes *Aechmophorus occidentalis* feed in freshwater habitats whereas tropicbirds *Phaethon* are oceanic feeders, having low $\delta^{18}O$ and high $\delta^{18}O$ respectively. In theory a long-term study could determine changes in feeding patterns (from freshwater to saltwater) based on isotope signatures of eggshells.

Isotope signatures in bird tissues are also affected by the trophic level of the organisms they eat. Hence, changes in diet can be detected by the analysis of museum specimens. Thompson *et al.* (1995) found that the relative abundance of ^{15}N in feather samples from Northern Fulmars *Fulmarus glacialis* in the north-east Atlantic declined between the early and late nineteenth century. The relative abundance of ^{15}N tends to increase with increasing trophic level, so this change implies that Fulmars have changed their diet to include a higher component of animals of low trophic level. Thompson *et al.* suggested that this might be due to the cessation of commercial whaling within range of the sampled colonies, although changes in the species or age of fish eaten might also explain the change in isotope ratio.

Nitrogen isotope signatures of eggshells can also be used to determine the diet of birds, as has been shown by feeding experiments (Hobson 1995). This technique could be applied to eggshells in museum collections to determine changes in diet over time. Emslie *et al.* (1998) suggested that eggshell fragments found in the sediment of abandoned penguin colonies could be used to determine changes in the prey items from different trophic levels (e.g. krill *vs.* squid *vs.* fish).

Limitations of museum collections in future ecological long-term studies

For ecologists to make use of avian collections in long-term studies they require information about available specimens. Ideally ecologists would have information on the number of specimens, localities and date of collection. Currently only a few readily available databases of avian collections exist. Examples include an inventory of major egg collections in the United States (Kiff 1979, Kiff & Hough 1985), and the online database of Manchester Museum (http://www.museum.man.ac.uk). Online databases appear more flexible and allow easy access to large datasets. Databases are needed to make ecologists aware of the potentially available data currently hidden in museum collections.

Few avian museum collections have had new specimens added to them in recent decades at rates that even approach those of the late nineteenth and early twentieth centuries (Remsen 1995, Winker 1996). Hence, future studies of long-term change will increasingly suffer from a gap in the data between the early spate of collecting and recent material, most of which has been specially obtained for a specific study. Indeed, for this reason many of the studies we have referred to above involve a comparison of measurements or analyses of old museum specimens with recent data from live-trapped birds. This problem obviously calls for careful storage and use of existing material, but a case can also be made for a revival in the accumulation of avian specimens as a resource for long-term ecological studies, provided that this does not have a negative impact on the conservation status of the bird species.

In some cases representative samples could be collected for a limited set of species at fixed intervals in time. This would involve a carefully coordinated collection effort with detailed recording of ancillary data on every specimen and the preservation of a range of tissues. An alternative or supplementary approach would be to encourage members of the public and amateur ornithologists, in particular ringers and nest recorders, to contribute dead birds and deserted and addled eggs they find incidentally to museums to a much greater extent than they do at present. Although this approach would not permit the use of stratified random sampling, it would have the advantage that specimens from a wide range of species could be obtained. Our perception is that this does not happen at present, at least in western Europe, because both the public and amateur ornithologists are not aware that new specimens are useful for research purposes or that museums are the places that can use them.

The potential of this latter approach is illustrated by the scheme to collect and analyse carcasses of raptors administered by the Centre for Ecology and Hydrology in the U.K. Advertisements for carcasses were placed in bird journals. This resulted in the collection of thousands of specimens over a period of more than thirty years, even though the population sizes of the species concerned are not particularly large. Although the primary objective was to obtain tissue samples for the analysis of pesticide residues (e.g. Newton *et al.* 1993), the specimens have also been used for long-term studies of population ecology (e.g. Newton *et al.* 1999, Wyllie & Newton 1999). Hence, we suggest that availability of new specimens need not be an impediment to the accumulation of a continuous series. A more pertinent question is probably whether museums now have sufficient resources, especially of staff, to prepare, document and store increased numbers of specimens.

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Sudden large samples: opportunities and problems

by Andrew C. Kitchener & Robert Y. McGowan

SUMMARY

Oilspills and other causes of mass mortalities in birds offer opportunities to study origins, biometrics, condition, pathologies and mortality impacts in populations, using statistically adequate samples; they also create problems of storage, availability of facilities and staff, funding and, most critically, labelling and cross-referencing. Experience at the National Museums of Scotland over 25 years, involving in particular divers, gulls, auks and buzzards, shows that the first crucial step is to buy time—although an inevitable expense—by freezing at least 20 specimens of each sex. If full study skins are too costly (or beyond the expertise of available staff) to prepare, preservation of the skeleton, one wing and sometimes the tail maximises opportunities for age, moult and other studies; but retaining the 'best' specimens may create biases. Preservation of muscle samples for later extraction of DNA is highly recommended. Publication of results should not be neglected, irrespective of time-lag since accession. Recommendations for procedures when processing oilspill samples are appended.

Introduction

Although the world's museums are filled with millions of bird skins, skeletons, spirit specimens and eggs, it is often difficult to find large enough samples to allow for comparisons between closely related species, subspecies or populations within species. Therefore, at a taxonomic level it can be almost impossible to determine whether apparent discrete geographical variation is real or an artefact of small, localised samples (Corbet 1970). It is also rarely possible to obtain information from existing collections on pathology, mortality or other aspects of population biology, which can be used to assist studies related to the management and conservation of species today and in the future.

In recent years at the National Museums of Scotland (NMS) we have had opportunities to study large samples of dead birds, many of which were subsequently preserved in a variety of ways for future reference. Most of these birds were either casualties of oilspills at sea or from natural 'wrecks' caused by extreme winter weather at sea. We are aware that other museums have been involved in analysing oiled dead seabirds, although few have placed an emphasis on specimen preparation as at NMS. In other cases samples have been collected over a few years by other institutions for specific studies and then passed on to NMS for our own use, or they have been the result of legal culls. In order to maximise the potential of these opportunistic samples, we have collaborated widely with other institutions and organisations, and consequently we have made samples available for a wide range of associated studies. From these large samples of birds we have carried out studies on age, sex, geographical variation/origins, hybridisation, pathology, diet, mortality, moult, etc., in collaboration with colleagues from the Universities of Edinburgh, Glasgow and

Liverpool John Moores, and the Institute of Terrestrial Ecology (now the Centre for Ecology and Hydrology).

Although large samples create opportunities, they also create huge problems in terms of storage of carcasses until needed, the availability of suitable facilities and casual staff to process the birds, sufficient funding to cover staff costs and materials and, most critically, the labelling and cross-referencing of multiple samples. We cannot claim to have solved all of these problems, but we offer our experiences to aid and warn others who might wish to embark on similar projects. In order to show the kinds of information that can be obtained collaboratively, we also briefly review the results of the various studies that have been carried out at NMS over the years on large samples of birds that have been acquired opportunistically and often suddenly.

Opportunities and problems

Large samples of birds often offer unique opportunities to look at populations in detail, which would not be possible under normal circumstances. Oilspills, in particular, cause mortality on a scale which would be considered unethical to cause intentionally for research purposes. By working with collaborators, it is possible to maximise the research potential of these samples. We have worked closely with veterinary pathologists from the University of Edinburgh to provide a greater insight into the effects of oil on seabirds and the frequencies of various natural diseases that afflict bird populations. By combining basic information on age, sex, moult and condition with pathological observations, we have been able to look at how pathology and mortality affect different segments of populations. We have also supplied fresh tissue samples for analyses of the concentrations of organochlorines and heavy metals, and for molecular studies.

In dealing with large samples, there are a number of logistical problems to overcome. Assuming that others have organised the collection of, for example, oiled seabirds and frozen them for future analysis, there are still the problems of finding sufficient funding to carry out a full analysis, suitable facilities where the preliminary processing of large numbers of birds can be carried out, and sufficient knowledgeable casual staff to work through the birds and prepare them. We were fortunate that in dealing with the dead seabirds from the *Braer* oilspill at Garths Ness, Shetland, in January 1993, Scottish Natural Heritage made a small grant available to finance the employment of a small number of experienced people for the preparation of voucher specimens. Local companies also gave materials generously for use at very short notice. In the case of the *Sea Empress* oilspill near Milford Haven in February 1996 we were contracted by the Countryside Council for Wales to work on the dead oiled seabirds, excluding the Black Scoters *Melanitta nigra*. However, in both cases the level of funding was less than ideal, and NMS covered much of the cost of recording and analysing data, preparing specimens and writing reports from its own resources. Our other studies on large samples (e.g. Common Buzzards *Buteo buteo* and Northern Fulmars *Fulmarus glacialis*) are being carried out over longer periods of time as staff and volunteer time become available. In all cases it has been absolutely essential that all the material is frozen, so that time can be taken to plan the work ahead and contact potential collaborators, who might need fresh tissue samples. Also, smaller batches can then be thawed out to be worked on, thereby preventing deterioration of the whole sample. This systematic approach ensures the maximum research benefit in terms of multiple uses of each specimen.

Suitable facilities for the sorting, measuring and sampling of birds are difficult to find. By collaborating with the Royal (Dick) School of Veterinary Studies, we were able to use their excellent pathology laboratories which have ample space for several people and good facilities for storage of specimens, washing down benches, etc., and disposal of unwanted material. In recent years we have used our own (similar but smaller) specimen processing and maceration facilities at our West Granton Research Centre.

We have found casual staff through a network of interested ornithologists, otherwise unemployed, and some students. Ideally, processing is delayed until student holiday periods, so that an abundance of willing workers can be found. This requires freezing of the carcasses for several months, which may be difficult. We have used commercial cold stores for this, which creates additional expense. We should also caution that disposal of oily/detergent water from cleaning specimens should be done by a responsible specialist contractor, so that other fauna are not affected by liquid waste that would otherwise have been disposed of down drains. Again this can create an additional and significant cost.

One of the key factors in the analysis of large samples is to preserve statistically adequate samples of skins and/or skeletons for later research; a minimum of 20 adults of each sex is essential, but many more would be desirable. However, resource constraints often severely limit how many specimens can be prepared. These samples provide good data on the extent of shrinkage of skin measurements, which allow for comparison between other published studies of living birds. In checking preserved samples, we also found that inevitably a few mistakes had been made in the fresh measurements, but voucher specimens ensured that these mistakes could be corrected. Moreover, in the heat of the moment it is easy to miss the significance of certain characters or impossible to take additional measurements or record moult, etc., especially if birds are badly oiled.

The preparation of full study skins can be very time-consuming and is a specialist skill. Therefore, particularly in recent years, we have preserved many specimens as skeletons, but have retained one complete wing for ageing, moult and measurements. For some species, complete tails were also preserved, where these aided ageing (e.g. Common Buzzard). The preparation of this type of specimen requires relatively unskilled staff and is much quicker than the production of conventional study skins. The total number of specimens for large samples prepared since 1978 (and mostly since 1993) is shown in Table 1.

One of the biggest problems after completion of studies like the ones described below is finding sufficient time to prepare papers for publication. We have been moderately successful at this (see References), but we are all too aware that many

TABLE 1
Numbers of specimens of bird species prepared by NMS from oilspills and other sources since 1978.

Species	*Esso Bernicia* 1978/79	*Braer* 1993	*Sea Empress* 1996	Other sources 1978–1998
Gavia stellata			20	
Gavia immer	68	11	2	
Podiceps cristatus				25
Fulmarus glacialis		16		40
Phalacrocorax aristotelis		71		
Somateria mollissima		68		
Clangula hyemalis		108		
Melanitta nigra			18	
Oxyura jamaicensis				47
Buteo buteo				180+
Larus argentatus		12		
Larus fuscus				25
Larus marinus		20		
Larus glaucoides		13		
Rissa tridactyla		90		100+
Alle alle		13		
Alca torda	5	4	20	
Uria aalge	51	7	114	
Cepphus grylle	119	126		

data still need to be analysed and several papers await completion, e.g. on Red-throated Divers *Gavia stellata* and Black Guillemots *Cepphus grylle*. It is vitally important to not only preserve specimens for future research use, but also to publish the results in the scientific literature.

Finally, the success of projects like the ones described in this paper often rests on the enthusiasm and determination of particular individuals. We have been most fortunate that the late Douglas Weir dedicated a great deal of his time, often for very poor remuneration, to driving forward our efforts on many of the projects described below. His considerable ornithological expertise and his fearlessness in the face of large piles of dead birds were essential to our success in recent years.

Oiled seabirds

NMS has been involved in studies on seabirds from three oilspills, the *Esso Bernicia* in 1979, the *Braer* in 1993 and the *Sea Empress* in 1996. The latter two spills involved the Pathology Department of the Royal (Dick) School of Veterinary Studies in pathological examinations of large series of seabirds. Several other collaborators were supplied with samples at the time or subsequently. The separate species accounts below summarise briefly the significant results of a wide variety of investigations.

Divers Gavia

NMS has prepared nearly 100 Great Northern Divers *Gavia immer*, mostly from the *Esso Bernicia* (1978–1979 at Sullom Voe) and *Braer* (1993) oilspills in Shetland. Wing measurements indicated origins of the *Esso Bernicia* oilspill birds by comparison with measurements from known breeding birds. Wintering Great Northern Divers off Shetland consisted of approximately 45% birds from Iceland, 45% from Greenland and 10% from Canada (Heubeck *et al.* 1993, Weir *et al.* 1996a). From the estimated total number of Great Northern Divers that died in this spill, it was estimated that 10% of breeding females from Iceland were killed, which represents a serious level of mortality in this long-lived, slow-breeding bird (Weir *et al.* 1996a).

We radiographed many carcasses in 1980 to detect lead shot, but in particular noted from skeletons from the *Braer* oilspill that many had non-fatal gunshot wounds, i.e. holes that were healing that had been created by bullets or shot. Because the carcasses of many of the *Esso Bernicia* birds had been retained, it was also possible to prepare their skeletons and check for similar damage. About 34% of birds had non-fatal gunshot wounds and, because we knew of the birds' origins, it was possible to observe some regional differences in the use of ammunition. The skeletons of birds that had probably originated in Canada invariably had holes made by .22 rifle bullets, but Icelandic birds had been damaged by shotgun pellets.

Auks Alcidae

The origins of about 200 Guillemots *Uria aalge* and Razorbills *Alca torda* were investigated from the *Sea Empress* oilspill. Wing and culmen measurements revealed that these were from local breeding populations. It was estimated that mortality would be insignificant (<5%), as was shown in the subsequent breeding season (Weir *et al.* 1997).

Gulls Laridae

About 50 Kittiwakes *Rissa tridactyla* killed by the *Braer* spill were determined as of high-latitude origin from wing measurements (Weir *et al.* 1996b) and hence their mortality had no impact on breeding populations in Shetland. This large sample of winter birds provided valuable new information on the moult cycle of the Kittiwake (J. Conner pers. comm.), and allowed the testing of a morphometric method for determining sex (McGowan & Zonfrillo 1995).

The *Braer* spill coincided with an apparent invasion of Iceland Gulls *Larus glaucoides*. Most were nominate *glaucoides*, but two were of the form *kumlieni*, which had varying amounts of wing-tip melanism. These observations inspired a review of Iceland Gull records in Britain (Weir *et al.* 1995), showing an apparent increase in the proportion of *kumlieni* in invasions since the nineteenth century. We also recently completed a taxonomic review of Iceland Gulls which demonstrates that *L. g. glaucoides* has been replaced by *L. g. thayeri* in the Canadian Arctic and that a variable hybrid (called *kumlieni*) appears to be spreading eastwards from Baffin Island (Weir *et al.* 2000).

Wrecks

Wrecks of dead seabirds occur regularly during the winter, although only in a minority of cases are the corpses utilised to their fullest potential. It would be valuable to study these in detail to see how in composition, pathology, etc., they differ from birds killed by oilspills. This could give a greater insight into which segments of populations of different species are vulnerable to these major causes of mortality. In 1997 a sample of 40 Northern Fulmars was collected from a localised wreck on the Northumberland coast. This large sample is currently the subject of a study of biometrics, origins and diet.

A sample of more than 130 wrecked Kittiwakes has also been collected recently from the Northumberland coast, which will complement origin, moult and other studies carried out on the *Braer* oilspill sample.

Samples collected by others

Common Buzzard Buteo buteo

We obtained more than 180 Common Buzzards from the Royal Society for the Protection of Birds (RSPB) and the Scottish Agricultural Science Agency (SASA). These had been collected over a number of years before being passed to us, thereby providing another opportunity for a combined morphometric and pathological approach. Scottish Natural Heritage kindly provided a small grant, which allowed the bulk of this study to be completed.

Preliminary findings have been published on a smaller sample of more than 60 birds, relating pathological findings to age and sex (Redrobe *et al.* 1997), and a paper on the full sample is currently in preparation. Most birds (55%) died from trauma or collision and starvation (23%). Poisoning was confirmed in 5% of birds (75% of those tested), although only suspicious deaths were investigated owing to the high costs of analysis. Gunshot wounds, not necessarily fatal, were present in 13% of birds. Most birds (73%) were subadults and most (74%) were male. This was thought to reflect the male offspring being driven out of parental territories and males participating more than females in aggressive territorial behaviour (for which see Weir & Picozzi 1975). These males have to survive in suboptimal habitats and consequently have a higher risk of death through, for example, foraging for carrion at roadsides. Diet was mostly small mammals (40%) and insects (17%). Parasites were recorded in 16% of birds, including only the second reported case in the species of the nematode *Cyathostoma*, which occurs in the orbital cavity.

Ruddy Duck Oxyura jamaicensis

Forty-seven cabinet skins were prepared from recently culled specimens of this duck from the British population. We feel it is important that a statistically adequate sample is taken for this introduced species, in order to determine any morphological changes that have occurred through local adaptation and also as a record of the species, if it is eventually exterminated.

Conclusion

Large samples provide excellent opportunities for gathering large amounts of data for a wide variety of studies. However, logistically and in terms of resources needed, they can be very difficult to carry out. We have been fortunate in that we do have facilities for specimen preparation and we have found enthusiastic collaborators, small grants and sponsorship-in-kind to assist our efforts. The reward has been to initiate many different research projects, which have made maximum use of each specimen, and which have resulted in statistically adequate samples of data-rich skins, skeletons and wings for our collections.

There is potentially plenty of material out there. What we all lack are the resources to access the abundance of data that could benefit environmental and conservation biology. We would like to see a contingency fund established by the oil companies to provide immediate support for detailed investigations like those described above. Ideally all available specimens would be preserved; we are concerned that preservation of the 'best' specimens may be biasing samples and unduly influencing our observations. These sudden large samples provide excellent opportunities for collaboration between museums and other research institutions, in order to maximise the potential for research and preservation of specimens. We would welcome further discussion and dialogue with our museum colleagues about how this can best be achieved.

Acknowledgement

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Appendix

Recommendations for the processing of dead bird specimens from oilspills

Plan the processing of the bird specimens well. It saves much time and effort, and ensures that data are not inadvertently lost. Ensure that all procedures and processes requiring COSSH* and risk assessments are considered prior to starting work. Ensure that all temporary staff are fully briefed, trained and have read the appropriate COSSH and risk assessments prior to starting work.

1. *Recording data*: Standard data sheets are recommended, in order to ensure that all data are recorded. We found that it was more effective having one person writing down the data recorded from one or more persons, because of the considerable mess caused by the oil. This limited contamination of data sheets by oil and facilitated the detection of anomalous data or measuring errors.

2. *Labelling*: It is essential that good labelling is used to prevent loss of data from specimens, especially while going through a variety of processes. We have used embossing tape (e.g. Dymo), aluminium tape or tags imprinted with numbered metal punches, and plastic plant tags with indelible ink. The latter are least successful as the ink may not quite survive the skeletonisation process. All parts of a specimen must be labelled, e.g. wing, skeleton, skin, etc.

3. *Samples*: The preservation of a muscle sample (e.g. pectoral muscle) for later extraction of DNA is highly recommended. NMS stores these deep frozen at “-40°C, although “-70 °C is recommended for long-term storage. Alternatively, thin slices of muscle can be preserved in 75% ethanol (not IMS [industrial methylated spirit] or formalin) at room temperature. Other kinds of samples may be required for other studies (e.g. for PCBs, heavy metals etc.). Have plenty of self-sealing sample bags available, on which informaton can be written. It is often useful to place labels in the bags in case the writing becomes obscured. It is vital to ensure that all samples are correctly labelled for later cross-referencing with other data and specimens.

4. *Measuring*: We recommend using plastic dial calipers for bill and tarsus measurements, as these can be cleaned more easily. As sand and oil are damaging to the calipers, they should be regulary checked for accuracy. Also, they are relatively low cost if they have to be disposed of. For wing measurements we recommend standard end-stopped rules (or similar) set into larger measuring boards. To ensure consistency, one individual was generally responsible for measuring.

5. *Protective clothing*: We have used paper boiler suits with disposable polythene aprons and huge numbers of latex gloves. Wellington boots are recommended as footwear.

6. *Sorting*: Although it is preferable to sample all specimens, this may not be practical owing to very large numbers, limited time and high cost. Inevitably, most effort is concentrated on specimens in good condition (even if heavily oiled), so that age and sex are most likely to be recordable. Badly decaying specimens may not be sexable and may pre-date the oilspill. Be aware that selecting the birds in best condition may inadvertently introduce a sampling bias, especially if males and females of a species arrive at a location at different times, or if body size and/or condition affect rate of decay.

7. *Measurements and external examination*: We record appropriate standard measurements from wing, tail, tarsus and bill. It is often not practical to measure body mass, because of oil, sand and water-logged plumage. Colouration of the irides and soft parts (bill, face and legs) are recorded if possible and appropriate. Relevant plumage characters are noted for ageing, etc.

8. *Internal examination*: A selected sample of the birds should be examined by an experienced avian pathologist. However, there may be some conditions that can be identified by most recorders with some training, e.g. aspergillosis. Crop contents are stored in 70% ethanol or deep frozen for later examination. Measurements of gonads (using dial calipers) involve length and width of testes and diameter of the largest ovarian follicle. We have attempted to get recorders to measure the bursa of Fabricius, but this was often difficult owing to heavy oil contamination and/or internal trauma caused by carcasses being crushed at the bottom of heavy storage sacks. The preparation of skeletons allows for later examination of skull ossification, but birds prepared for skins should have their skull ossifcation recorded at the time of preparation. Subcutaneous and internal fat deposits are recorded subjectively on a four-point scale from 0 to 3. As birds begin to decay rapidly once thawed, it is important not to thaw out too many birds for a daily examination otherwise valuable data may be lost.

9. *Removing the oil from specimens*: We have used petrol, paraffin and powerful detergents to remove oil from plumage. Appropriate COSSH and risk assessments need to be carried out for all processes prior to working on the dead seabirds.

10. *Preparing skeletons*: We have used autoclave bags in order to keep skeletons separate during maceration at 60°C. We have generally preserved one wing from each skeletonised bird, so that wing length, moult and other plumage features can be recorded. This allows for later examination and also for the measurement of wing shrinkage to facilitate a suitable correction factor.

11. *Clearing up*: All animal waste should be bagged in appropriate polythene sacks, labelled with a description of the contents and the address of the institution they have come from, before being incinerated. Note that plastic waste and latex gloves may have to be incinerated separately and should be bagged and labelled separately. Waste oily water should be left to settle in plastic drums, so that the oil can be decanted off for disposal by a specialist company.

*Control of Substances Hazardous to Health

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A global distributed biodiversity information network: building the world museum

by A. Townsend Peterson, David A. Vieglais, Adolfo G. Navarro Sigüenza & Marcos Silva

SUMMARY

Biodiversity information is not presently managed in a manner that enables or encourages broad, efficient, or novel uses. New technologies that permit integration of biodiversity information stored at institutions worldwide into a single biodiversity information facility, however, have the potential to change this situation. Information integrated from diverse institutions and available in quantity greatly empowers a diversity of novel products that amply demonstrate the importance of the information resource. We discuss the promise and the opportunity, as well as the impediments to assembling a global distributed biodiversity information network—effectively a 'world museum', built from the world's biodiversity and available to all freely and openly.

Introduction

This paper serves to present a major initiative to share biodiversity information on a global scale. This effort takes the form of a distributed data network implemented over the Internet, permitting full access to biodiversity information to all. The network can be seen as a move towards open collaboration by biodiversity scientists, and simultaneously as repatriation of information about biodiversity from the countries holding that information to the countries where that biodiversity exists in nature. The first element of this network was made openly available for worldwide access and use in April 1999—called *Species Analyst*—and is accessible at http://speciesanalyst.net/. It is a project that has grown out of the perception of the need for much-improved information services in the biodiversity world, and has been adopted and driven forward by a number of institutions around the world. The purpose of this paper is to outline the dimensions of the data network, stimulate discussion about its implementation, and promote participation by institutions across Europe.

History

Biodiversity exploration has seen many biases and imbalances geographically. The vast storehouse of biodiversity—species diversity and unique taxa—is in the tropics. The storehouses of biodiversity information and collections, however, are in the Northern Hemisphere, principally in the United States and Europe.

The scientific exploration and documentation of biodiversity began in earnest in the 1700s. The early explorations were initiated by Europeans, later joined by investigators from the United States. These explorations were often carried out without participation of scientists from the host countries, and information was often not returned to or shared with scientists in those countries. Lack of collaboration with, or training of, scientists in biodiversity-rich countries further widened the gap in information and expertise. Hence, specimens and scientific literature important to understanding world biodiversity became concentrated in countries where relatively little diversity was actually present.

The present

Biodiversity data are currently available in a dispersed system based on institutional and national boundaries. Most members of the community of data caretakers (curators in natural history museums and herbaria) are more than willing to provide information; nevertheless, the system is simply inefficient and difficult to access. For this reason, biodiversity studies have not taken full advantage of the information in existence.

Most biodiversity information is stored in the form of scientific collections in museums and universities across North America and Europe. This information is often not computerised, and is considered the property of individual institutions. Hence, access to each collection must be handled on a one-by-one basis, making access to the totality of information in existence a laborious task.

When assistance or access to data is requested, most biodiversity information caretakers make information and specimens readily available (Navarro-Sigüenza *et al.* 2002). Requests are accepted by mail or by electronic mail, or visitors are received in most collections; in some cases, data are made available freely over the Internet (Soberón 1999), but some voices still speak strongly against this idea (Graves 2000). The distributed nature of the collections, with important specimen holdings in 10–20 countries for most regions of interest, makes such communications or travel difficult or even prohibitive for most biodiversity information users, particularly those from where the information originated.

To illustrate the importance of complete biodiversity information, reference can be made to the avian dataset for Mexico under preparation as the *Atlas of the distribution of Mexican birds* (Peterson *et al.* 1998). Here, the contents of 43 scientific collections were assembled in a centralised database, totalling more than 300,000 specimen records for the country. The largest single collection held only 16% of the total, so the emergent properties of the large dataset were not realised until the contents of numerous collections were aggregated. Since its assembly, however, this dataset has been instrumental in advances both in conservation and in basic biology regarding Mexican birds (Peterson *et al.* 1999, Navarro-Sigüenza & Peterson 2000, Navarro-Sigüenza *et al.* 2002, Peterson *et al.* 2002a).

In recent years, several programmes aimed at improving the state of biodiversity informatics have emerged. *Species2000* (http://www.sp2000.org.) and the *Integrated Taxonomic Information System* (ITIS) (http://www.itis.usda.gov/plantproj/itis) aim to produce a catalogue of all named *species* in the world, but manage only information related to the *names* of the species, not to their distributions, occurrences or ecology. At present, four Internet-based facilities provide a novel form of 'distributed' access to biodiversity data: databases located at the institutions that 'own' the data (and the specimens most often associated with them) are probed by Internet-based search algorithms. These facilities include *The Species Analyst*, as well as Red Mundial para la Información de la Biodiversidad (REMIB) (http://www.conabio.gob.mx), the Virtual Australian Herbarium (http://www.rbgsyd.gov.au/HISCOM/Virtualherb/virtualherbarium.html) and the European Natural History Specimen Information Network (ENHSIN) (http://www.nhm.ac.uk/science/rco/enhsin) all provide broad access to such primary data. Most recently, the Global Biodiversity Information Facility (GBIF) was formed to seek means of integrating biodiversity information on a global scale, and has adopted much of the distributed model as the basis for its work.

At present, the information services in the world of biodiversity information is woefully inefficient. Data exist in impressive quantities for many taxonomic groups, yet this information is too often difficult to access. Because of the numerous impediments to access, biodiversity data are too frequently not included in studies and reports that would benefit immensely from their inclusion. This information gap leads both to an information undernourishment in many policy decisions, and a lack of appreciation of the immense value of biodiversity information held in, for example, natural history museums. Large-scale biodiversity conservation studies, although focusing on exactly the information in question, are often based only minimally, or secondarily, on biodiversity data. For this reason, such studies lack analytical power and information completeness, and the results often reflect this failing. For these reasons, we propose the expansion of the worldwide distributed biodiversity information network to include a broad sampling of European institutions, thus uniting data sources in North America and Europe.

The Species Analyst

Technology

The most complete representation of global biodiversity can be found in the world's natural history museums. Although records for museum collections are increasingly maintained in electronic format, their use has been hindered by the lack of standard methods for search and retrieval from disparate databases. Using ANSI/NISO Z39.50, a standard for information retrieval that has proved successful in the bibliographic and geospatial domains, and a newer information transfer protocol called XML, it is now possible to search and retrieve information from biological collections connected by the Internet.

The Species Analyst is a set of software extensions that enable Z39.50 searches from a web interface, as well as from applications such as Microsoft Excel and ESRI's ArcView GIS. Users may query multiple collection databases simultaneously and, in a matter of seconds, obtain information directly into a client application in a form suitable for further analysis. This suite of capabilities provides an infrastructure that allows seamless search, retrieval and analysis of a wealth of biodiversity data that has hitherto been impossible. Although at present data are served 'as is'—that is, names are provided as the owner institution has them, and are not at present integrated, translated or otherwise standardised; eventually, connections with efforts designed to assemble up-to-the-minute names catalogues will provide this next generation of data access.

The Species Analyst currently provides seamless access to more than 50 million specimens in 84 datasets housed at 65 institutions. Committed to participation are an additional 69 institutions with datasets principally focused on mammals, reptiles and amphibians. Hence, the total of biodiversity data now committed to participation is well over 130 institutions and approximately 55 million species-occurrence records. Additional millions of species-occurrence records are served via REMIB, Virtual Australian Herbarium, and ENHSIN, making for a substantial quantity of biodiversity information available worldwide to all users, and most vouched by specimens in scientific collections. The customary figure cited for total specimens in world natural history museums is about three billion, and best calculations are that about 5% of those specimens are now computerised (Krishtalka & Humphrey 2000); by this reasoning, about 150 million specimen records exist in electronic form, about 30% of which are served or slated to be served by *The Species Analyst*.

Applications of the distributed biodiversity network

The present situation of compartmentalised data and inefficient access constitutes a critical bottleneck in biodiversity applications. Once data are united in large, inclusive sets, many new possibilities open up for analysis, leading to new dimensions of understanding. These new possibilities can be referred to as 'emergent properties' of large biodiversity datasets, and further underline the need to enable the information currently present in natural history museums, as well as to continue building natural history museum collections. Three examples focused in the area of biodiversity conservation are presented below.

Endangered and poorly known species

In contrast to endangered species in many developed countries (Godown & Peterson 2000), many species of conservation concern are so poorly known or so rare that basic distributional information is unavailable. This problem is even more frequent in taxonomic groups less well known than birds. These species clearly present a most difficult challenge for biodiversity conservation, given that even the most basic information is often lacking.

An excellent example of a poorly known bird species is the Slaty Finch *Haplospiza rustica* of tropical America. Although more frequently encountered in the South American portion of its distribution, its known occurrences in Mexico and northern Central America are vanishingly few (Howell & Webb 1995). Populations are so poorly known that study and documentation of their taxonomic status, ecological characteristics and conservation status are essentially impossible.

Among scientific specimens of Slaty Finches, two Mexican point localities are available (Jalapa, Veracruz, in the 1860s; Volcán Tacaná, Chiapas, in the 1950s) from Mexico. Modelling the ecological requirements of the species using GARP (Stockwell & Noble 1992, Stockwell 1999, Stockwell & Peters 1999, Peterson *et al.* 2002b), a map of potential distributional areas for the species can be developed (Fig. 1). Although this map is very general, and probably overly inclusive given a possible connection with stands of bamboo, it provides a useful first step in outlining areas for search and inventory for the species in field efforts. In this particular case, a recent record (G. Escalona-Segura unpubl. data.) coincided exactly with one predicted potential distributional area (see arrow, Fig. 1). Using better-known species, these predictive methodologies have been put to more rigorous, statistical tests (Peterson *et al.* 2002b), providing convincing evidence that distributional models can be developed for many rare and poorly-known species.

Conservation prioritisation

Once the possibility exists of predicting geographic distributions of species with precision, a clear next step is that of predicting distributions of suites of species of

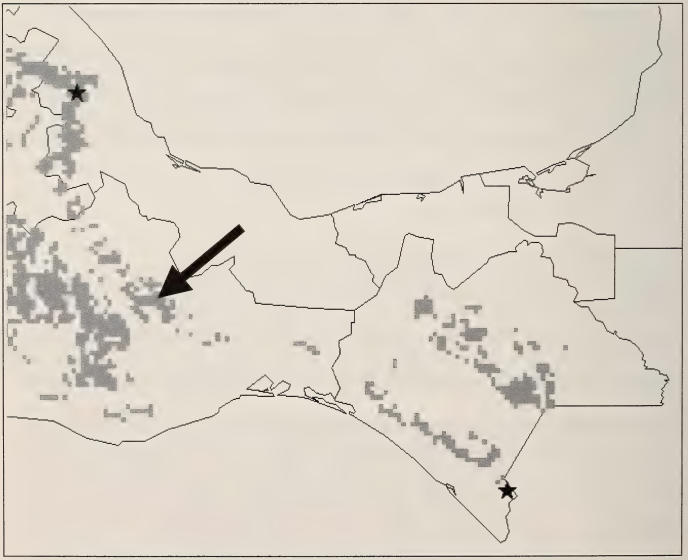

Figure 1. Distributional prediction (grey shading) for Slaty Finches *Haplospiza rustica* in Mexico based on two known specimen localities (black stars), showing third site discovered in 1995 (arrow).

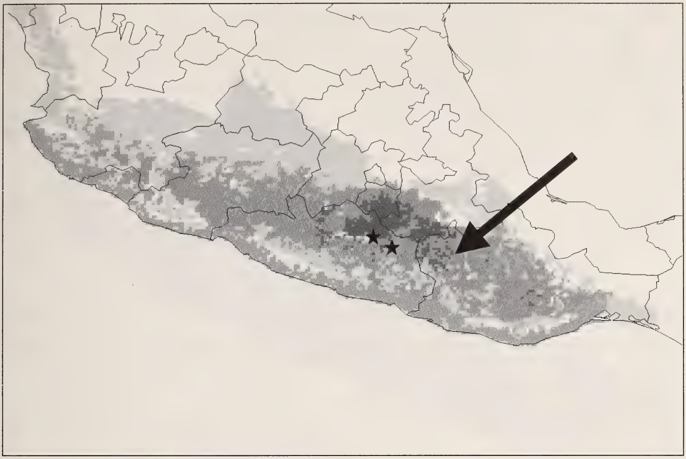

Figure 2. Richness of 16 species endemic to western Mexican tropical dry forests, showing increasing species richness as darker shades of grey. Locations of two biosphere reserves are shown with stars, coinciding with primary concentration of 12 species; the arrow indicates a secondary concentration, in which all four remaining species are represented.

special interest, and taking their joint distribution as conservation priorities. For instance, one might model the distributions of all endangered or endemic species in a region, and then identify resulting foci of species co-occurrence as priority areas. This approach has important advantages over past approaches (e.g. Bojórquez-Tapia *et al.* 1995), in that individual species' distributions are the input into the decision-making process, allowing the design of truly inclusive reserve systems, perhaps using algorithms aimed at maximising complementarity among areas (Peterson *et al.* 2000).

As an example of these possibilities, Kluza & Peterson (unpublished) modelled the geographic distributions of all 16 bird species endemic to the dry tropical forests of south-western Mexico. Individual species' distributions were overlaid, and a map of endemic species richness was created (Fig. 2). One area on this map in northern Guerrero (labelled 'A') represented a peak of species richness, including 12 of the 16 species; this area coincided well with two existing biosphere reserves. The remaining four species, however, were not protected by any biosphere reserves, and co-occurred in north-western Oaxaca. This area, in particular if avian patterns are coincident with those in other taxonomic groups, could be taken as a clear priority area for conservation action (Kluza & Peterson unpublished).

Global climate change and conservation planning

As a further demonstration of the flexibility and promise of the data and analytical approaches described herein, a final level of complexity can be added, taking into account the influence of global climate change on species' geographic distributions. Global climate change, rather than being simply 'global warming', rather represents a series of reorganisations of climatic processes, and therefore requires a series of complex modelling efforts. This work provides a first step towards a robust methodology.

In the GARP modelling process employed above, distributional predictions are derived from models of distribution in ecological dimensions, effectively a model of the ecological niche of the species (Peterson *et al.* 2002b). To the extent that ecological niches present stable sets of constraints on species' distributions over moderate periods of time (e.g. Peterson *et al.* 1999), distributions of species in a changing environment may be taken as the distributions of their ecological niches through those changes. Projections of these niche models to modeled future climates provide estimates of future potential distributions of species (Peterson *et al.* 2001, Peterson *et al.* 2002a).

As an illustration, we have modelled the potential future distribution of West Mexican Chachalaca *Ortalis poliocephala* under two scenarios of change in the Hadley simulation (Pope *et al.* 2002) of global climate change (50 yr of 0.5–1.0%/ yr CO_2 increase, with and without sulphate aerosol forcing). The present geographic distribution (Fig. 3) is more or less continuous along the western coast of Mexico. Through the simulated scenario of climate change, however, although coastal portions of the species's modelled distribution remain intact, the interior portions of Mexico become largely uninhabitable for the species. Of species that we have modelled similarly (Peterson *et al.* 2001, 2002a), we see a diversity of responses, including extinction, fragmentation and expansion. The conservation prioritisations presented above, then, would have to be adjusted to take into account these modified expectations of species' distributions over very short horizons of time.

The proposal

The goal

The principal objective of the *Species Analyst* and related efforts to build a global distributed biodiversity information system is to spark collaboration and cooperation among biodiversity scientists via open access to biodiversity data. The project will effectively end the present compartmentalised system, in which access to information is on an institution-by-institution basis, and move the field towards worldwide integration—a virtual 'world museum', in which barriers to information access disappear. Information taken from countries over several centuries will become openly accessible to all, effectively constituting repatriation of biodiversity data. Matching improved access to information with open sharing of expertise and software

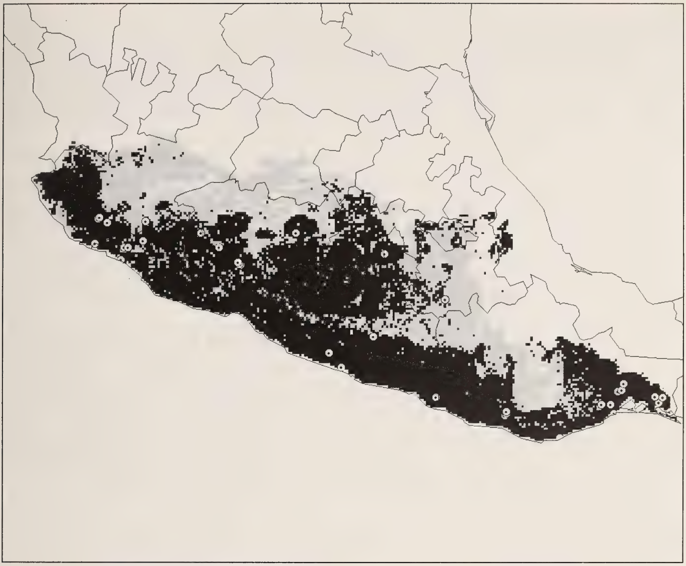

Figure 3. Projected effects of global climate change on the geographic distribution of the West Mexican Chachalaca *Ortalis poliocephala*: present distribution is shown in grey and black, and projected post-change distribution is in black; specimen-based distributional points are shown as dotted circles.

will lead to a qualitative leap forward in ability to use biodiversity information effectively.

Whereas most North American institutions are participating, at least in part, in *The Species Analyst*, few European institutions are currently linked to the network. Although European distributed data initiatives are beginning (e.g. ENHSIN), they lag behind the American efforts in serving a major portion of the biodiversity information stored in European institutions. Clearly, this difference derives from a variety of reasons. However, prominent among them is the fact that very few European natural history museum collections are at present computerised, obviously making serving data impossible. (Of course, it should be pointed out that several important American bird collections are also not computerised—e.g. American Museum of Natural History—or are only partially computerised—e.g. U.S. National Museum of Natural History—so the contrast is not entirely black *versus* white!)

An action plan

For each European institution potentially interested in participating, the procedure for integrating data via the distributed database systems is quite simple. Basic requirements are (1) electronic data, (2) Internet connectivity, and (3) the institutional 'will' to share data. In particular, it will be necessary to identify collections that have been computerised to a degree that participation is possible.

Institutions wishing to participate and holding appropriate datasets will need to fulfil three conditions. First, data must exist in electronic format. Second, the data must be on a computer with a reasonably fast Internet connection (i.e. not based on a phone modem connection) (in cases in which fast Internet connections are available at other institutions nearby, it may be possible to deposit copies of collections databases for serving from those institutions). Finally, the data must be in a database management system that accepts SQL (Standardised Query Language) queries, permitting a base level of access to the information.

The actual connection process is relatively simple. For the present, consultation with technicians working for one of the distributed data networks is necessary. Generally in an afternoon or so of consultation, the appropriate software can be installed, and data are connected in short order. These software packages are still in phases of development, and for that reason the process still requires some technical expertise; soon, however, the connection process should be considerably simpler, with software installed and configured in a point-and-click environment.

Future view

The Internet, through developments such as *The Species Analyst*, offers for the first time the possibility of widespread integration of information in existence worldwide about biological diversity. These advances make possible a rapid shift from the previous situation (closed institutional resources) to an exciting new one—information can be integrated across regional, national, taxonomic and institutional boundaries to provide a resource never before possible. Already, this improved access to information has been instrumental in stimulating novel approaches to predicting species invasions (Peterson & Vieglais 2001), design of endangered species conservation efforts (Godown & Peterson 2000), design of efforts to combat agricultural pests (Sánchez-Cordero & Martínez-Meyer 2000), understanding ecological niche evolution (Peterson *et al.* 1999), and predicting the effects of global climate change on species distributions (Peterson *et al.* 2001, 2002a), etc. In this way, the totality of biodiversity information can be applied to critical questions, such as biodiversity conservation, natural resource management, land use planning, and others.

These steps remove a critical impediment—that of access to information—and allows scientists and decision-makers worldwide to proceed to new levels of understanding. Data served over the distributed network can be improved via iterative sweeps of standardisation, adding value, and error detection, which can serve to improve the information resource markedly. We expect these shifts in how biodiversity science is 'done' to make possible large-scale improvements in the quality of information products and scientific studies based on biodiversity information. In the shorter term, these new tools can provide the medium for cooperation among many institutions, uniting scientific efforts in North America and Europe with similar efforts elsewhere.

Significance

The basic principle of the *Species Analyst* data network is that of *free and open access to data and technology*. The development of the network has depended on combining this philosophy with careful political negotiations and innovative technologies. The result is a network that has grown rapidly to serve a significant portion of existing data in natural history museum collections worldwide. Taxa in the data network include mammals, birds, reptiles, amphibians, fish, butterflies and other insects, and plants. The network is growing rapidly, and is on track to become an all-taxon, worldwide distributed biodiversity data network. In this paper, we have illustrated some of the possibilities that open up to investigators once data are shared openly and integrated with modern tools. In the field that we chose for illustration (biodiversity conservation), synthetic models were developed that greatly exceed present capabilities for most regions. Moreover, because of the open-frame approach of the data network, these possibilities exist for almost any region and taxon on earth, without great investment of time and resources to obtain data for analysis.

As a postscript to this contribution, the original manuscript was prepared in 1999, in the midst of a period of rapid development, in both technology and politics of biodiversity information. On the technological side, many important advances have been made in making the software solutions broadly applicable, stable, fast and reliable. Several distributed biodiversity information networks now exist, and many are collaborating on a next-generation technology that should allow integration of all of the networks into a single global distributed biodiversity information network. On the political side, some aspects have changed dramatically, and others have *not* changed dramatically. On the side of change, the initiation of the Global Biodiversity Information Facility has emphasised the need for participation in data-sharing efforts within each member country, and has sparked many exciting steps forward in the assembly of efficient biodiversity information services around the world. On the side of *no* change, some workers in the field—including curators at important and large natural history museums—continue to resist the idea of bringing natural history museums into the information age. One can only hope that these persons and their ideas can evolve as the idea of global sharing of such important information becomes more and more the rule, and no longer the exception.

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Treasure Island—the rise and decline of a small tropical museum, the Mauritius Institute

by Anthony S. Cheke

SUMMARY

In early nineteenth century Mauritius—the Indian Ocean island famous for the Dodo—Julien Desjardins and other local naturalists made collections of Mascarene biota, much of which is now extinct. This material formed the basis of a museum opened to the public in 1842. It was moved, together with a new public library, to the purpose-built Mauritius Institute in 1885. Throughout its first 140 years the collections, including many rare, unique and often irreplaceable specimens, were expanded and generally well looked after, until the early 1980s when cumulative underfunding and seriously inappropriate management led to a very disturbing deterioration of the collections, with specimens being lost and destroyed. Remedial action to stabilise what remains is technically simple but less straightforward socio-politically. As similar problems exist in many parts of the world, a 'Red List' of endangered collections should be compiled to provide a basis for prioritised action, and twinning museums at risk with well-endowed ones might also prove useful. [As the text was written in 1999, a postscript on recent remedial action to late 2002 is added.]

Introduction

In the sixteenth and seventeenth centuries when museums were young and preservation techniques rudimentary, it was standard practice to throw out decayed specimens and replace them with new. Such a clear-out is popularly supposed to have taken place at Oxford's Ashmolean Museum in 1755, when the unique but decaying stuffed Dodo *Raphus cucullatus* is said to have been consigned, with other specimens, to be destroyed (MacGregor 1983). "By a lucky accident ... the head and one of the feet were saved from the flames" (Strickland & Melville 1848)[1].

We would not, however, expect this kind of thing to happen today, and yet I regret to say that the same story in fact applies to the recent history of the Mauritius Institute, the museum in the very land from which those Dodos came—one of the oldest museums in the Southern Hemisphere and one whose collections are literally, like the Dodos, irreplaceable.

Mauritius is an isolated volcanic island of some 1,865 km², situated in the Indian Ocean at 20°S, 840 km east of Madagascar. Together with Réunion (164 km south-west) and Rodrigues (574 km east), it forms part of the group known as the Mascarene Islands (Montaggioni & Nativel 1988, Strahm 1996), which although rather far-flung have a strongly coherent biota, and are famous for their distinct (and largely extinct) endemic fauna (Cheke 1987a,b, Quammen 1996). This highly endemic wildlife survived into historical times because the islands escaped the attentions of human colonists until the late sixteenth century.

The histories of Mauritian and Mascarene wildlife, ornithology and museums have been intertwined since the beginning. The very first public museum in Britain, John Tradescant's 'Ark' in Lambeth (founded around 1630, and later absorbed into Elias Ashmole's museum in Oxford) contained what were then unusual objects of preservation, stuffed birds: among them was a Mauritian Dodo, one of a number to reach England in the 1620s/1630s (MacGregor 1983, Cheke 1987a). Its head and foot remain to this day the oldest surviving example of a bird skin. A specimen of an extinct Réunion tortoise was brought alive to Paris in 1671, and its carapace, the type of *Testudo indica*, survives there (Austin *et al.* 2002). Rodrigues, in 1690, was the scene of the first recorded account of territoriality in birds—Leguat's observations on the soon-to-be-extinct Solitaire *Pezophaps solitarius* (Armstrong 1953, Cheke 1987a). Birds from Réunion formed an important part of the *Cabinet du Roi* in Paris described by Brisson in 1760, and that decade also saw, on both Mauritius and Réunion, the first known example of biological control: Common Mynas *Acridotheres tristis* were introduced in 1767 to control locusts, and were given legal protection (another first) to ensure success (Cheke 1987a). French naturalists based on the islands corresponded with Buffon and others in Paris, and a number of scientific expeditions made collections in the 1700s and early 1800s (Cheke 1987a).

Origins of the natural history museum in Mauritius

By the early 1800s a number of naturalists were active in Mauritius and making collections. These included Charles Telfair, polymath, ex-ship's doctor, sometime Colonial Secretary for the island and sugar planter (Michel 1935), who had the ear of the new British administration. His own material, given to the Zoological Society of London, was dispersed and largely lost when the Society's collections were sold in 1855 (Wheeler 1997). In 1826 Telfair prompted two local collectors, zoologist Julien Desjardins and botanist Louis Bouton, to offer their material to the state, in the form of the British Governor Sir Lowry Cole, to form the core of a proposed 'colonial museum'. This generous offer met with no response from the Governor, however, so in 1829 Telfair invited Bouton, Desjardins and other local naturalists, notably botanist/explorer Wenceslas Bojer and seafaring zoophile François Liénard (all names very familiar to anyone who knows the Mascarene lizard fauna), to a meeting at which the Société d'Histoire Naturelle de l'Ile Maurice was founded (Ly-Tio-Fane 1972). Desjardins, who had meanwhile set up a museum privately in his own house on his estate at Argy (Flacq district; Bouton 1877), went to Paris in 1839 to write a natural history of the island, but died there prematurely in 1840. His widow, determined that the collection should remain in Mauritius to honour her husband's dedication, presented his collections to the Society (Bouton 1842). Bouton added his plants, and together with Adrien d'Epinay's library (also recently left to the Society), the ensemble was finally opened to the public in 1842 as the Muséum Desjardins, in a wing of the Royal College in Port Louis, with Bojer as curator (Pike 1873, Ly-Tio-Fane 1972). This time the government provided the space and also half of the salary of the curator and his taxidermist (Ly-Tio-Fane 1972). Bouton (1851) reported that 4,278 people visited the museum in its first five years; at the time only some 10,000 of the island's population (the white ruling class and some of the creoles: Toussaint 1972) would have been allowed access to the Royal College and had sufficient education to be interested in a museum.

Visitors from abroad often commented on the collection. Mouat (1852) called it an 'excellent museum ... worthy of his [Bojer's] great and widely established reputation'. By contrast in 1862, Edward Newton, colonial official and ornithologist, wrote disparagingly to his brother Alfred (soon to be professor of zoology at Cambridge) that 'it is quite disheartening [to have] anything to do with the museum, there is not a soul who cares or knows about ornithology in the island, though perhaps some of them would be most offended at my saying so' (MS letter book in the Alfred Newton papers, Cambridge University Library). Although Newton was later president of the Society in the 1870s (*Trans. Royal Society of Arts and Sciences of Mauritius, passim*), he never contributed any collections to the museum. Nicholas Pike (1973), American consul, naturalist and raconteur, was more upbeat: 'The natural history collections of the Society in their museum are fine and rare, but not extensive. Besides the fauna of Mauritius, that of Madagascar, southern Africa and the neighbouring islands is well represented.'

Despite the initial goodwill, the new museum was seriously underfunded. Bojer died discouraged in 1856; the indefatigable Bouton took over, but it was not until 1863, with the arrival of Sir Humphry Barkly as Governor, that things began to improve (Bouton 1877). Finally, in 1877, Governor Sir Arthur Phayre made proposals for a purpose-built museum, and accepted a report from the Society (by now the Royal Society of Arts and Sciences of Mauritius [RSAS]) recommending that a new institution be set up to comprise the museum and a public library, and to have in addition a dedicated educational function (RSAS 1878), to be fully funded by the government. Ordinance No.19 of 1880 (see *Mauritius Almanac* for 1881) provided for 'the erection, establishment and regulation of a Mauritius Institute, a Public Museum and Public Library' to promote 'the general study and cultivation of the various branches and departments of arts, science, literature and philosophy, and for the instruction and recreation of the people'. The Governor was authorised in the Ordinance to vote funds to 'erect within the town of Port Louis a building' to house the Institute; the result was the construction of a fine new edifice in a very prominent central site in the capital, which was bought and cleared of existing buildings (Macmillan 1914). Work began promptly, and the new Mauritius Institute was formally opened (two governors later) in December 1884 for a colonial exhibition, with the museum and library moving there in January 1885 (Daruty 1885, Koenig 1939, Ly-Tio-Fane 1979). They are in the same building today, although the Institute now also controls two other smaller museums containing historical, artistic and other material (Tirvengadum 1980).

The importance of the collections

One might imagine that a small museum in a small country would contain little of international importance, but with the Mauritius Institute this is very far from the case. I do not propose to list all its treasures, and indeed I do not know what unique invertebrates it may still contain, but any *one* of the following would justify a special place on a world level of collections. The museum contains (Cheke & Jones 1987, Cowles 1987, Staub 1993) the only extant skeletons of the large extinct flightless rail *Aphanapteryx bonasia* and the extinct giant skink *Leiolopisma* (*=Didosaurus*) *mauritiana*; one (the last individual ever recorded) of only three specimens of the extinct endemic Pigeon Hollandais *Alectroenas nitidissima*; a Réunion Starling *Fregilupus varius* (extinct and one of only 18 or so surviving specimens); one of the very few specimens of the probably extinct monotypic endemic burrowing boa *Bolyeria multicarinata* from Round Island; two good Dodo skeletons (including the only one articulated solely from a single individual) and a general collection of extant endemic vertebrate fauna which is not particularly well represented in any other museum. The pigeon and starling come from Desjardins's original collection; one Dodo from Théodore Sauzier's excavations in 1891–1892; the other, with the rail and the skink, from Mauritian barber Etienne Thirioux's spare-time excavations around the turn of the century and first exhibited in 1903 (d'Emmerez de Charmoy 1903, Koenig 1939).

The birds held in the museum were enumerated by Rountree *et al.* (1952) and again (data collected 1974–1983) by Cheke & Jones (1987); it would be interesting to repeat the census today. In addition there are extensive collections of insects, marine invertebrates and fish, although the highly endemic land-snail fauna, of which many representatives are already extinct (Griffiths 1997), is under-represented (pers. obs.). The herbarium (originally Bouton's) was removed to Pamplemousses Gardens in 1868—where it was disastrously curated and almost ruined in 1899 when thrown into rat-infested outhouses to make way for a temporary isolation hospital—and only returned to the Institute in the mid-1930s after having been rescued and sorted by Reginald Vaughan (Vaughan 1969). In 1960 it was combined with two other collections as the Mauritius Herbarium, under Vaughan as curator, and installed in air-conditioned premises at the Mauritius Sugar Industry Research Institute (MSIRI) at Le Réduit (Vaughan 1969).

Recent history of the Mauritius Institute

When first established in the 1880s the museum was under a Board of Directors with quasi-independent status under the Colonial Secretary. In 1929 a proposal by the Board to become a formal Government Department (Ingrams *et al.* 1929) was not acted on, though the public displays were re-worked (Koenig 1939). In 1940 a new ordinance restructured the Board and its functions (Michel 1980). However, in 1957 the museum was attached to the Ministry of Education and Culture, and in 1967, the year before Mauritius became independent, a Public Service Commission was established which relieved the board of its ability to choose staff (Michel 1980, Tirvengadum 1980). Apart from a hiatus from 1913 to 1941 during which W. E. Hart, followed by his son the poet Robert Edward Hart (literary figures without any knowledge of natural history) were in charge (Tirvengadum 1980), the curatorship has always been given to a notable local biologist or naturalist (who also oversaw the library). Nonetheless, during the Harts' curatorship, local naturalists were very actively involved in the running of the natural history collections (Ingrams 1929, Koenig 1939). In 1946, following the 1940 ordinance, the new senior post of director was established, under whom served the curator and a librarian. The first incumbent was Dr Reginald Vaughan, founder of plant ecological studies in Mauritius, followed by Jean Vinson, an entomologist and herpetologist who did much to draw attention to the uniqueness of and threats to Round Island, and then by marine biologist Claude Michel, who has devoted a lifetime to science education in Mauritius. Unfortunately when Claude Michel, already curator, succeeded to the directorship, it then took the Public Service Commission 12 years to appoint a new curator! (Michel 1980).

On the occasion of the Institute's centenary in 1980 the then director, botanist Deva D. Tirvengadum, reminded fellow Mauritians that one of the Institute's functions was 'the preservation, enrichment and systematic study of all its precious collections', and that the 'functions of conservation, research and education are tied to the good curation of collections'. He continued prophetically: '...the essential task is to protect the collections from all forms of deterioration and the various attacks from *men* or the elements to which they could be victim' (Tirvengadum 1980; my translation and italics). Emphasising the need to understand the real value of the collections, he complained that the staffing was 'primordial', and that it was essential to restructure the concept of museums in Mauritius, have proper technical consultative back-up, and apply for funds from UNESCO and other international bodies.

Tirvengadum's article was an outburst from a discouraged successor to Bojer; he left shortly afterwards for pastures abroad, his clear call for remedial restructuring ignored. The dire result of depriving the Board of Directors of appointing powers was then made all too evident with the failure of the Public Service Commission to find and appoint a new director. The then curator, R.Gajeelee, a zoology graduate but without training in museum or library management, was left in charge as acting director, a position he continued to occupy for nearly 20 years.

In 1982, faced with deteriorating conditions and losses of priceless books, the Royal Society of Arts and Sciences of Mauritius, which had been so instrumental in founding the Institute, removed its library to new secure air-conditioned premises adjacent to the Herbarium, provided by the MSIRI (RSAS 1983). I visited the Institute in 1985 to consult a manuscript and was struck by the disarray in its archival collection. By the time of my next visit in 1996, some major improvements had been made in parts of the public display area and one of Andrew Kitchener's thin Dodo models acquired. However, stories from local naturalists alleged that the museum's reserve collections were being totally neglected, and that specimens of rare endemic species were being thrown away because they were supposedly 'moth-eaten'. The *Mauritius Institute Bulletin*, a reputable vehicle for local faunal and biological studies since 1937, edited by the director, had not appeared since 1984; Gajeelee had published only one issue. In 1997 and 1998 two senior visiting British museum curators confirmed the lamentable conditions. One reported to me that museum staff proposed to throw away an alcohol specimen of the extinct endemic snake *Bolyeria multicarinata* (one of about 6 in the world) because the head broke off when the brittle specimen was removed from its bottle. Clearly the museum had lost curatorial perspective.

This situation has had direct and negative repercussions for Mauritian science. Since 1973 there has been a pro-active international wildlife conservation project in place on the island (Jones & Hartley 1995), coinciding with the beginning with the British Ornithologists' Union Mascarene Islands Expedition (Diamond 1987). Initially there was active collaboration with the museum (pers. obs. 1973–1975, C. G. Jones pers. comm.) but during Gajeelee's tenure, the project, currently under the umbrella of the Mauritian Wildlife Foundation, became increasingly wary of involvement with the museum, and took to sending all valuable specimens abroad. Such specimens, and those deriving from captive-breeding projects at Jersey Zoo, still technically belong to the Mauritius Government (Cooper *et al.* 1998). Meanwhile, in total contrast, the now properly curated Mauritius Herbarium, under the auspices of the MSIRI, thrives, and has played a pivotal part in the compilation of a major new Mascarenes flora, the *Flore des Mascareignes* (Bosser *et al.* 1976–), in collaboration with the Royal Botanic Gardens, Kew in the U.K. and ORSTOM in France. No equivalent faunal collaboration would be possible under recently prevailing conditions, whereas in neighbouring Réunion the equivalent (and almost equally valuable) Muséum d'Histoire Naturelle under Sonia Ribes and [in 1999] Mathieu Le Corre is actively involved in projects with overseas institutions.

I returned to Mauritius in early June 1999 to work on a book project with a colleague. We went with some trepidation to the museum, only to discover that the acting director had died in post a fortnight earlier; he had allegedly been physically and mentally unfit for some years, but had nonetheless been allowed to remain in office. The Commission moved quickly to appoint a successor, S. Abdoolrahaman, who was thought to be in line for the permanent job. In my conversations with him in June 1999 it was clear that he was fully aware of the museum's plight and well disposed to receiving foreign aid to help get the museum back on its feet.

The museum in Réunion has been recently renovated (1995–1996), exploiting regional assistance money available in Paris for such projects (pers. obs. 1973–1999; S. Ribes pers. comm.). This is of course easier in an overseas *département* of France than for independent Mauritius, but it provides a model for what could be done in the Mauritius Institute. I have no doubt that funds for such a project could be found in the EC, UNESCO or the Commonwealth—the only stumbling block being that the request for the aid must come from the Mauritius Government. In fact, Mauritius did commission the University of Texas to report on the future of the museum in around 1996 (S. Abdoolrahaman, pers. comm., June 1999), but the recommendations have been neither disclosed nor implemented. A French-funded consultant, Emmanuel Richon, has been working with the Mauritius Institute's three museums for the last two or three years reorganising the public displays in a more 'modern' idiom; at the time of writing [November 1999] he had not reached the natural history section, although he has been instrumental in getting the main building re-roofed (it had been leaking for years). However, his brief was with educational displays, and he did not have much to do with the reserve collections.

Constraints and solutions

Many people in Mauritius were long aware of the problem with the museum, but felt unable to act. One reason is its system of governance, since the lack of executive power placed the Board of Directors, however well-intentioned, in an impossible situation. It is also the case that, as in many other parts of the world, those working with or in government are reluctant to jeopardise their projects or jobs by raising the issue of the museum, however bad they may personally feel about it. Moreover, there is an understandable cultural difficulty resulting from the numerical and political dominance of a community originating from immigrants from India. Many feel stronger historical ties to the subcontinent than to the European colonial history of an island whose endemic fauna and flora was largely destroyed by western colonists long before the period of Indian immigration began (1830s: Toussaint 1972, Addison & Hazareesingh 1993). Recent governments have given higher priority to a museum and institute commemorating Mahatma Gandhi, though he only visited the island once, briefly, in 1901 (Addison & Hazareesingh 1993). Low official interest in the lost native biota may also be unconsciously related to the fact that average Mauritians (of whatever ethnic origin) see so little of it in their daily lives. Every familiar flower, tree, snail, insect, mammal or bird—bar a few butterflies, one bird and a couple of bats and palms—is an exotic, and has been since their great-great-grandparents' lifetimes. What they think of as typically Mauritian plants and animals are the everyday tropical species they meet in their gardens and countryside, whereas the endemics seen in the museum are as foreign to them as kangaroos or ostriches.

Is the museum more important to Westerners than it is to Mauritians? The West should perhaps overtly acknowledge its central role in the destruction of Mauritian wildlife, and its enduring interest in preserving the lost remnants of that biota in the museum. The natural history museum in Mauritius is in essence a European cultural and historical legacy, and perhaps it lies with Westerners to help maintain it, as has already been implicitly accepted in the international conservation programmes devoted to protecting the surviving native wildlife. In reality, of course, there are many Mauritians who fully understand and support the museum, and some sort of partnership must therefore be possible. Perhaps a way forward might be for the concerned museum fraternity to compile a kind of 'Red List' of underfunded and endangered museums and collections. It should be emphasised that these are by no means all in developing countries— in seeking an old Mauritian specimen I well recall the dismal plight of the Hancock Museum in Newcastle, U.K., in the 1970s[2] (see also Jessop 1999). This list could then be used to *offer* assistance to places housing such collections, in much the same way as wildlife conservation projects are often initiated and run. 'Twinning' a well-appointed museum with a less favoured one, as is often done between towns, might also provide benefits and a useful interchange of personnel and ideas.

Postscript, October 2002

With minor adjustments, the above account remains more or less as it was written in 1999, as trying to update it within the text would have resulted in a loss of the immediacy that formed an important part of its message when given as a talk at the conference. However, things have moved on, and the following postscript brings the situation up to date, bearing out the more optimistic outlook immediately evident following the appointment of Mr Abdoolrahaman.

Following the leak of a draft of this paper to the Mauritian press in May 2000, prompting a critical article by Marylène François in *Weekend* on 4 June, the Acting Director wrote me a pained letter asking for specific details, which I supplied. This exchange triggered, or at least accelerated, action to rectify the 20 years of dereliction. The Netherlands was already funding archaeological work under Dr Peter Floore on seventeenth-century Dutch settlement sites; bird and mammal bones were turning up in their middens, and it was a natural extension to look towards the subfossil bones kept in the Port Louis museum. At Mr Abdoolrahaman's invitation, the project funded Julian Hume of the U.K. Natural History Museum (Tring), who was already working on the Dutch bird bones, and was the colleague who had visited the museum with me in 1999, to make a rapid survey in June 2001 of the reserve collections to assess their status and make recommendations for their proper curation. Hume's brief report (Hume 2001) reveals that while some of the missing items (e.g. bird skeletons) had simply been hidden in an inaccessible attic, other specimens were indeed in a deplorable state: butterflies and some mounted skins were ruined by damp and pests, and the spirit collection, containing much lizard type material (Vinson & Vinson 1969, Cheke 1975), had completely dried out. Some progress had already been made in rescuing skin and insect specimens and treating them with insecticide. There was no time then to make an inventory (so allegedly missing bird skins were not checked), but a Dutch member of Dr Floore's team is currently at work in the museum (J. Hume pers. comm.), and hopefully the new enthusiasm and international collaboration will result in the restoration of the museum's reputation and its central place in Mauritian biology.

It has also recently been announced (Maureemootoo 2002) that the *Mauritius Institute Bulletin* is to be re-launched in early 2003, reviving after nearly 20 years' absence this important local vehicle for faunistic and floristic studies.

Footnotes

1. Although widely disseminated and believed this story is not actually true. Ovenell (1992) has documented through archival records the real version, in which new curator William Huddesford was doing his duty in preserving what could be preserved of deteriorating specimens, in the Dodo's case the head and foot; effective preservation techniques had yet to be discovered. There was no fire—this was a colourful invention of Strickland's. In the early 1700s there were two other stuffed

Dodos in Oxford, in the Anatomy School (MacGregor 1983)—these did indeed disappear without trace (A. V. Simcock, pers. comm.).

2. Marmaduke Tunstall, whose collections formed the basis of the Hancock Museum, had a live Mauritius Fody *Foudia rubra* in his aviaries in the mid-1700s, later preserved as a mounted specimen, when it was illustrated by Peter Brown (1776). The skin was there in 1827 (Fox 1827), but had long vanished (together with most of the rest of Tunstall's birds) by 1977 when I looked for it. To bring this insectivorous bird alive to England at the time was a remarkable feat—it was the first Mauritian passerine to reach Europe.

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Museums working together: the atlas of the birds of Mexico

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SUMMARY

The present contribution is a case study of the application of data from world scientific collections to understanding the distribution, systematics and conservation of Mexican birds. Information was gathered on specimens from Mexico housed in 58 scientific collections in Mexico, the United States, Canada and Europe. This information was compiled in a centralised data base, and GIS programs used to visualise general geographic patterns and address historical patterns of ornithological investigations. We used the 'Genetic Algorithm for Rule-set Prediction' to predict current and potential distributional areas of species, patterns of species richness, endemism and seasonality, and conservation applications. The avifaunal inventory of Mexico is impressively thorough, but many areas are poorly represented in collections. Now, however, quantitative approaches to inferring into undersampled areas are available and offer many new insights into the biogeography of the region. These results suggest the possibility of developing new research products based on point-occurrence data from natural history museum collections.

RESUMEN

La presente contribución representa un estudio de caso de la aplicación de la información obtenida de colecciones ornitológicas de todo el mundo, para entender la distribución, sistemática y conservación de las aves de México. Se recopiló información sobre ejemplares mexicanos alojados en 58 colecciones científicas en México, Estados Unidos, Canadá y Europa. Esta información se conjuntó en una base de datos centralizada, la cual fue georreferenciada y se realizaron diversos análisis en SIG para visualizar los patrones geográficos generales y patrones históricos de la investigación ornitológica en México. Se usó el algoritmo GARP que, basado en los puntos de ocurrencia, permite realizar modelos predictivos de la distribución de las especies que involucran la construcción y descripción de las áreas de distribución actuales y potenciales de las especies, así como el estudio de los patrones de riqueza, endemismo, estacionalidad y aplicaciones en conservación. El inventario de la avifauna mexicana está muy avanzado, pero muchas zonas están poco representadas en las colecciones. Estos resultados sugieren la posibilidad de desarrollar nuevas investigaciones basadas en los datos de puntos de ocurrencias alojados en ejemplares de las colecciones.

Introduction

Mexico holds an astonishing biological diversity, ranking among the so-called megadiversity countries (Mittermeier *et al.* 1997). This richness originates in the geographic location of the country between two major biogeographic regions, Nearctic and Neotropical, that intergrade broadly in the area. Perhaps more importantly, the complex topography—coastal plains, mountain ranges, high plateaus, and islands—and geological history of the region produce a wide array of ecological conditions and favour the development of isolated populations and the action of *in* *situ* evolutionary processes. Thus, a high proportion of the biota of the country is endemic (Ramamoorthy *et al.* 1993).

In recent years, interest in surveying the biological resources of the country has increased greatly, with the goal of creating a national strategy to preserve biodiversity. Inventories and analyses of geographic, ecological, taxonomic and genetic diversity are key issues towards this goal (Soberón *et al.* 1996). Birds form important components of ecosystems, and are widely used as examples of what biodiversity studies *could* achieve because they are excellent ecological indicators and are well known taxonomically and distributionally.

To achieve these goals, the enormous quantity of information scattered across the world in the scientific literature and scientific collections must be assembled. Our main goal was to create a database aggregating data from Mexican bird specimens worldwide, and to develop analyses that illustrate the potential increase in understanding of biogeography, systematics and conservation of the birds of Mexico. We see this effort as a prototype for even broader efforts, eventually encompassing the entire world and numerous taxa, developed by the entire community of systematic biologists and biodiversity scientists in a massive collaborative effort.

The ornithological framework

Mexico is favoured with great bird diversity. Avian species richness, under the biological species concept, is estimated at 1,074, 107 of which are endemic to the country (Escalante *et al.* 1993, AOU 1998). Recent taxonomic revision, however, using alternative species concepts, has raised the number to 1,250 species, 229 of which are endemic (Peterson & Navarro 1999). Some of the endemic forms belong to 10 endemic genera (*Philortyx*, *Rhynchopsitta*, *Deltarhynchus*, *Rhodothraupis*, *Ridgwayia*, *Mimodes*, *Euptilotis*, *Hylorchilus*, *Calothorax* and *Xenospiza*), as well as genera recognised by some taxonomists, such as *Neochloe*, *Aechmolophus* and *Amaurospizopsis* (Friedmann *et al.* 1950, Miller *et al.* 1957). This richness is distributed in the country in very interesting patterns (Peterson *et al.* 1992, Escalante *et al.* 1993, Peterson *et al.* 1998): whereas highest species richness is concentrated in tropical regions in the south-east, endemism is highest in the islands, south-western tropical dry lowlands, and the mountains (Peterson & Navarro 1999).

Several species, both endemic and non-endemic, are considered globally threatened (BirdLife International 2000). Such taxa are often highly restricted geographically (e.g. Short-crested Coquette *Lophornis brachylopha*), inhabit highly endangered habitats (e.g. Horned Guan *Oreophasis derbianus*), or are threatened by hunting or illegal trade (e.g. Military Macaw *Ara militaris*). Six Mexican bird species are considered globally Endangered (Socorro Mockingbird *Mimodes graysoni*, Bearded Wood-partridge *Dendrortyx barbatus*, Short-crested Coquette *Lophornis brachylopha*, Guadalupe Junco *Junco insularis*, Black-capped Vireo *Vireo atricapillus* and Dwarf Jay *Cyanolyca nana*: BirdLife International 2000). An additional 13 species are listed as Vulnerable (e.g. Socorro Parakeet *Aratinga brevipes*, Maroon-fronted Parrot *Rhynchopsitta terrisi*, Nava's Wren *Hylorchilus navai*: BirdLife

International 2000). To date, extinctions include the Slender-billed Grackle *Quiscalus palustris* (Dickerman 1965), Guadalupe Caracara *Caracara lutosus* (Greenway 1967, Iñigo-Elías 2000a), and San Benito House Finch *Carpodacus 'mexicanus' mcgregori* (Jehl 1971). The Guadalupe Storm-petrel *Oceanodroma macrodactyla* and Imperial Woodpecker *Campephilus imperialis* are considered Critically Endangered (BirdLife International 2000) but are almost certainly extinct (Ceballos & Márquez 2000); and the Socorro Dove *Zenaida graysoni* is extinct in the wild. The Red-throated Caracara *Ibycter americanus* (Iñígo-Elías 2000b) and California Condor *Gymnogyps californianus* (Koford 1953) have been extirpated in Mexico (Ceballos & Márquez 2000, Ríos-Muñoz in press).

How do we know all this?

All of this information, constituting a basic resource for innumerable applications to wildlife conservation, is scattered across a multitude of sources (Peterson *et al.* 1998). Moreover, it is often unavailable to researchers, especially those in developing countries. Scientists and conservationists require information, including geographic locations of species' occurrences, ecological characteristics and conservation status, in order to develop research. The scientific literature is an important source, although biased by the fact that most formal publications on Mexican birds have appeared in foreign journals and in non-native languages, especially English, French and German (Rodríguez-Yáñez *et al.* 1994). A second and more widely distributed resource is that of field guides; these, however, are also generally in English and only provide generalities of the geographic range and ecology of species. Third, observations by birdwatchers and ornithologists would provide a rich resource, but are seldom published, organised, or made available in a useful fashion.

The most important sources of information regarding biodiversity are scientific collections (Peterson *et al.* 1998). The specimens that have accumulated through decades in many institutions worldwide constitute a critical baseline dataset for biodiversity studies. Indeed, the role of museums as caretakers and disseminators of this information, too often overlooked or underestimated recently, is gaining importance for several reasons. One is that the specimen record was obtained across diverse ecological and historical conditions, providing a rich record of past and present biodiversity phenomena. These specimens hold information relevant to identification, geographic location and historical distribution that can be *verified* by subsequent researchers. This basic reference and historical material for studies in avian systematics, ecology, evolution, genetics, biogeography, biodiversity, and conservation research and planning, thus have an enormous potential for diverse applications.

A bit of history

The history of ornithological investigations in Mexico was reviewed by Navarro (1989) and Escalante *et al.* (1993), and is summarised briefly here. Knowledge of the Mexican avifauna started with the indigenous cultures that inhabited the country.

At the time of the arrival of the Spanish *conquistadores*, most of the diversity of Mexican birds had been discovered by the people of different regions in Mexico, because birds played important roles in their daily activities, foods and religion. Monks and scientists from Spain, such as Fray Bernardino de Sahagún and Francisco Hernández, compiled indigenous knowledge on Mexico's natural resources (Alvarez del Toro 1985).

Further expeditions were made by the Spanish in the seventeenth and eighteenth centuries, and by French, German, British and Italian naturalists in the nineteenth century. On these trips, specimens were accumulated (as were field notes and paintings) that are now housed in Paris, Vienna, Berlin, Bremen, Cambridge, Turin, Madrid and elsewhere. The end of the nineteenth century saw the beginning of intensive exploration of Mexican biodiversity, particularly by English and U.S. scientists. Osbert Salvin and Frederic DuCane Godman coordinated the *Biologia Centrali-Americana*, a multi-volume description of Central American flora and fauna, of which four volumes were dedicated to birds (Salvin & Godman 1879-1904). The collections amassed were the product of fieldwork by themselves and by many collectors that they hired in the region, as well as by purchases of collections. Most of these specimens are now housed at the Natural History Museum in the United Kingdom.

Edward Nelson and Edward Goldman, from the United States National Museum in Washington, D.C., explored Mexico's natural resources as part of the United States Biological Survey. Thousands of bird specimens were accumulated, and updated information on ecology and biogeography of the species and communities was assembled (Goldman 1951). Their work sparked intense interest in the Mexican avifauna in the first half of the twentieth century. In this period, several professional collectors (e.g. Chester Lamb, Wilmot W. Brown, Mario del Toro Avilés) and researchers from many institutions in the United States and Canada visited different regions within the country and made important collections. The most important collections are those at the Moore Laboratory of Zoology, American Museum of Natural History, Field Museum of Natural History, Museum of Vertebrate Zoology, Museum of Comparative Zoology, University of Michigan and Louisiana State University.

More recently, several Mexican or Mexico-based researchers, particularly at the National Autonomous University (UNAM), further improved the knowledge of Mexican birds (e.g. Allan R. Phillips, Rafael Martín del Campo). Today, a young and active ornithological community is developing at many institutions, adding to the ecological, systematic and geographical knowledge of Mexican birds. Centres of ornithological research with important collections are located in Mexico City (UNAM and Instituto Politécnico Nacional), Monterrey (Universidad de Nuevo León), Morelia (Universidad Michoacana), and Chetumal and Tuxtla Gutiérrez (ECOSUR and Instituto de Historia Natural), among others. Given this history, the scattered and locally unavailable nature of information about Mexican birds is very clear; yet the need for such information is enormous, as many conservation-related initiatives are taking place in Mexico as part of regional and international efforts, as well as for basic research.

Methods

Data were obtained from 58 scientific collections in Mexico, United States, Canada and Europe (Table 1) with the generous assistance of curators at each institution, often by direct visits; of these datasets, information from 40 has been cleaned, standardised and incorporated into a single data resource (Fig. 1). Data were obtained in different forms, depending on the collection. We were able to obtain electronic copies of the holdings of 21 collection databases that were already computerised in various formats (Dbase, Excel, ACCESS or ASCII files). In very large and uncomputerised collections, we consulted the original collection catalogues and checked data against the actual specimens. A few collections were surveyed through the scientific literature, especially those for which catalogues of extinct, type or all specimens had been published. Most commonly, however, we captured data directly from the specimens, allowing checks of identification, locality, sex and age of the specimens. This capture and updating of data is an ongoing job, and several Mexican (e.g. ECOSUR) and foreign collections (e.g. Russian Academy of Sciences) are waiting to be included in the main database.

Records from scientific literature were obtained from an exhaustive survey of some 4,000 references on Mexican birds produced between 1825 and 1999 (Rodríguez-Yáñez *et al.* 1994). Specific occurrence records were drawn from 312 recent references (1986–1999) that updated the distributional information on many species, especially in poorly known areas (e.g. islands in the Gulf of California), and performed by observers that we deemed experts (e.g. E. Mellink, H. Gómez de Silva). This literature survey accounted for 8,900 individual georeferenced records (3.4% of the total records used for this contribution). A relational database was constructed that contained basic fields available from most specimens and bibliographic records (Fig. 2). For each record, taxonomy was updated to a recent version of the biological species concept (AOU 1998), as well as to a new treatment based on the phylogenetic/evolutionary species concepts (Peterson & Navarro 1998).

TABLE 1

Summary of 58 natural history museums contributing Mexican bird specimen records to the database described in this paper. Note that numbers reported represent the number of records in the *Atlas* database, and do not necessarily represent the total of specimens in the institution. Museums included in the analyses presented in this paper are indicated with asterisks (*) and n/a indicates information not available yet.

Institution	country	species	specimens
Moore Laboratory of Zoology, Occidental College*	USA	806	43,297
Museum of Comparative Zoology, Harvard University*	USA	958	21,261
Instituto de Biología, Universidad Nacional Autónoma de México	Mexico	n/a	24,000
Natural History Museum, Tring*	UK	889	19,386
Louisiana State University Museum of Natural Science*	USA	949	17,808
Delaware Museum of Natural History*	USA	891	16,711
American Museum of Natural History*	USA	907	15,803
University of Michigan Museum of Zoology	USA	800	13,312

Western Foundation of Vertebrate Zoology*	USA	858	12,597
Field Museum of Natural History*	USA	889	12,067
Bell Museum of Natural History, University of Minnesota *	USA	734	11,636
Museo de Zoología, Facultad de Ciencias, UNAM*	Mexico	672	10,431
Museum of Vertebrate Zoology, University of California*	USA	314	9,221
University of Kansas Museum of Natural History*	USA	762	8,504
United States National Museum of Natural History*	USA	672	8,296
Universidad Michoacana San Nicolás de Hidalgo *	Mexico	413	8,296
Carnegie Museum of Natural History *	USA	783	8,192
California Academy of Sciences	USA	611	6,655
San Diego Natural History Museum*	USA	451	6,518
University of California, Los Angeles*	USA	459	5,560
Cornell University Laboratory of Ornithology	USA	657	5,068
Canadian Museum of Nature *	Canada	534	4,643
Peabody Museum, Yale University*	USA	654	4,298
Muséum Nationale d'Histoire Naturelle, Paris*	France	633	4,016
Los Angeles County Museum of Natural History*	USA	633	3,364
Southwestern College, Winfield, Kansas *	USA	557	2,549
Florida Museum of Natural History	USA	535	2,326
Royal Ontario Museum*	Canada	551	2,188
Academy of Natural Sciences, Philadelphia*	USA	547	2,084
University of British Columbia Museum of Zoology*	Canada	267	2,016
University of Arizona*	USA	450	1,657
Texas Cooperative Wildlife Collections *	USA	324	1,347
Forschungsinstitut Senckenberg, Frankfurt	Germany	n/a	1,339
Museum für Naturkunde, Berlin	Germany	463	1,320
Museo de la Biodiversidad Maya, Campeche	Mexico	180	1,024
Übersee-Museum, Bremen	Germany	300	957
Denver Museum of Natural History*	USA	166	675
Museo Regionale di Scienze Naturali, Torino	Italy	n/a	632
Burke Museum, University of Washington, Seattle	USA	218	548
Staatliches Museum fur Naturkunde, Sttutgart	Germany	n/a	484
Museo Nacional de Ciencias Naturales, Madrid	Spain	186	470
Natuurhistorische Museum, Leiden*	Holland	137	327
Muséum Nationale d'Histoire Naturelle, Genève	Switzerland	n/a	307
Museum Koenig, Bonn	Germany	n/a	267
Museo La Specola, Università di Firenze	Italy	n/a	212
Zoologische Staatssammlung, Munich	Germany	n/a	210
Museo di Storia Naturale, Genova	Italy	n/a	206
Russian Academy of Sciences, St. Petersburg	Russia	n/a	196
University Museum of Zoology, Cambridge	UK	112	148
Fort Hays State College, Kansas*	USA	75	120
Manchester Museum, Manchester	UK	n/a	87
Nebraska State Museum*	USA	55	87
Museo Civico di Storia Naturale, Milano	Italy	18	23
Iowa State University, Ames*	USA	9	22
Moscow State University Museum	Russia	17	17
Darwin Museum, Moscow	Russia	9	9
Museo Federico Craveri, Bra	Italy	n/a	n/a

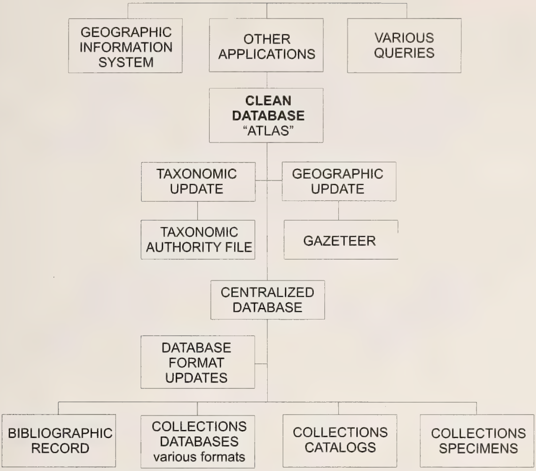
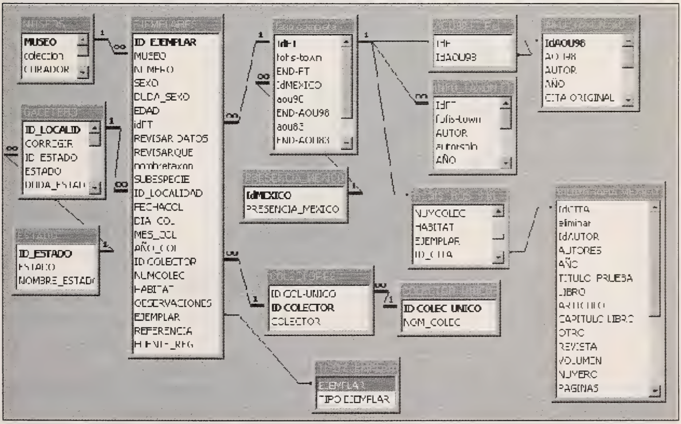

GEOGRAPHIC INFORMATION SYSTEM
OTHER APPLICATIONS
VARIOUS QUERIES
CLEAN DATABASE "ATLAS"
TAXONOMIC UPDATE
GEOGRAPHIC UPDATE
TAXONOMIC AUTHORITY FILE
GAZETEER
CENTRALIZED DATABASE
DATABASE FORMAT UPDATES
BIBLIOGRAPHIC RECORD
COLLECTIONS DATABASES various formats
COLLECTIONS CATALOGS
COLLECTIONS SPECIMENS

Figure 1. Sources and information flux in the *Atlas* database: raw data input is shown at the bottom, and updated and edit ascending in the middle; the resulting clean database and applications are shown at the top.


MUSEO
colección
CURADOR
ID_LOCALID
CORREGIR
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ESTADO
DUDA_ESTAD
ID_ESTADO
ESTADO
NOMBRE_ESTAD
ID_EJEMPLAR
MUSEO
NUMERO
SEXO
DUDA_SEXO
EDAD
idFT
REVISAR DATOS
REVISARQUE
nombretaxon
SUBESPECIE
ID_LOCALIDAD
FECHACOL
DIA_COL
MES_COL
AÑO_COL
ID COLECTOR
NUMCOLEC
HABITAT
OBSERVACIONES
EJEMPLAR
REFERENCIA
IDENT_REG
IdFT
toFs-toAn
END-FT
IdMEXICO
aou9C
END-AOU98
aou83
END-AOU83
IdMEXICO
PRESENCIA_MEXICO
IdFT
IdAOU98
IdAOU98
AUTOR
AÑO
CITA ORIGINAL
IdFT
toFs-toAn
AUTOR
autorsub
AÑO
NUMCOLEC
HABITAT
EJEMPLAR
ID_CITA
IdCITA
eliminar
IdAUTOR
AUTORES
AÑO
TITULO PRUEBA
LIBRO
ARTICULO
CAPITULO LIBRO
OTRO
REVISTA
VOLUMEN
NUMERO
PAGINAS
ID COL-UNICO
ID COLECTOR
COLECTOR
ID COLEC UNICO
NOM_COLEC
EJEMPLAR
TIPO EJEMPLAR

Figure 2. Relational structure of the *Atlas* database.

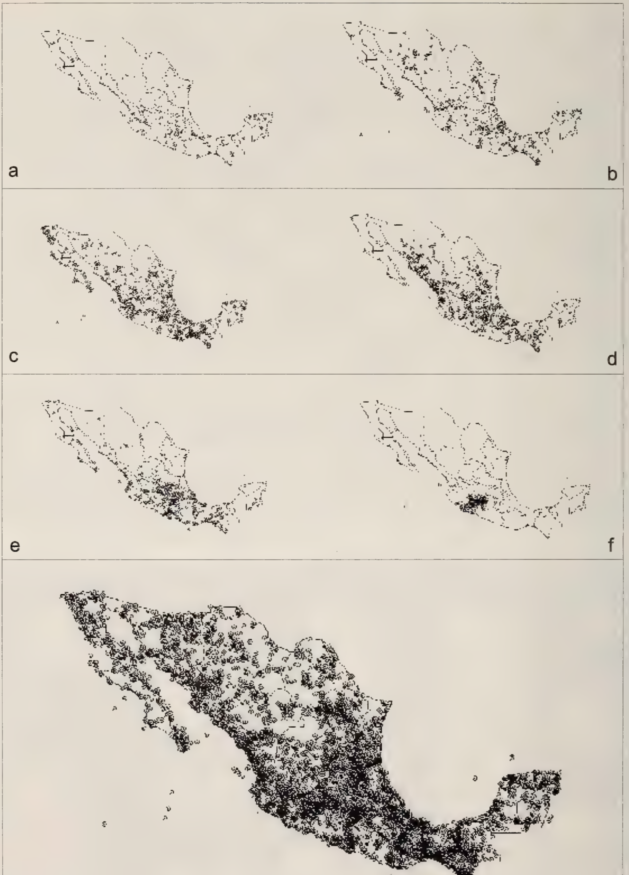

Figure 3. Geographical distribution of specimen data from selected scientific collections. (a) Muséum Nationale d'Histoire Naturelle, Paris; (b) American Museum of Natural History, New York; (c) Natural History Museum, Tring; (d) Moore Laboratory of Zoology, California; (e) Museo de Zoología, Facultad de Ciencias, UNAM, Mexico; (f) Universidad Michoacana, Morelia, Mexico; (g) sum of locality data from 40 institutions in the *Atlas* database.

Once records were captured, an extract of unique localities was performed to obtain a gazetteer or geographic authority file. This file included all unique combinations of state, locality and elevation. Latitude and longitude data (as decimal degrees) for each unique locality were obtained using 1:250,000 maps of the country (INEGI 1988). Correct locations of localities for which multiple sites had the same name in a state were determined with the help of published gazetteers (e.g. Paynter 1955) or original field notes. Of an initial total of more thyan 36,600 unique localities, 94% were successfully georeferenced.

Once the database was constructed, 248,000 of 250,000 records were selected. Those for which (1) identification and locality was not doubtful from 40 museums and (2) data had already been incorporated into the centralised database were used to develop the analyses that follow. To visualise general geographic patterns we used ArcView (ESRI 1999). Digital cartography was made available by the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). Analyses involving predictive distributional areas were performed using the Genetic Algorithm for Rule-set Prediction (GARP: Peterson *et al.* 2003, this volume).

Results

Representativeness of collections

How well represented are the birds of Mexico in each scientific collection? Biodiversity analyses require abundant information that is rarely available from a single data source. Particular collections specialise on a particular state (e.g. Universidad Michoacana), or have broader coverage (e.g. Moore Collection, Fig. 3), and indeed no single collection contains sufficient geographic or taxonomic representation to develop a full analysis (Peterson *et al.* 1998). However, accumulation of localities across the 40 data sets included in our studies leaves few major areas unsampled, providing much more complete ornithological information. Now, with increasing quantity and availability of observational information, visual records can complement the specimen record to provide further detail (Fig. 4).

Although this analysis may suggest that the avifaunal inventory of Mexico is satisfactorily complete, we plotted localities for which more than 100 specimens (an arbitrary measure) are available (Fig. 5). The resulting pattern is interesting because the gaps are much wider, and many areas of Mexico are clearly still poorly represented in collections. The database also provides a valuable resource for guiding systematic studies. For example, specimens of the different forms of Common Bush-tanager *Chlorospingus ophthalmicus* (Sánchez-González 1999) are scattered widely among institutions (Fig. 6). Using an information resource such as the one we have developed, a researcher may easily detect key specimens for a particular study, thereby maximising efficiency.

Distributional patterns

Georeferenced specimen occurrence data can easily be retrieved into geographic information systems applications, permitting association of biological data with

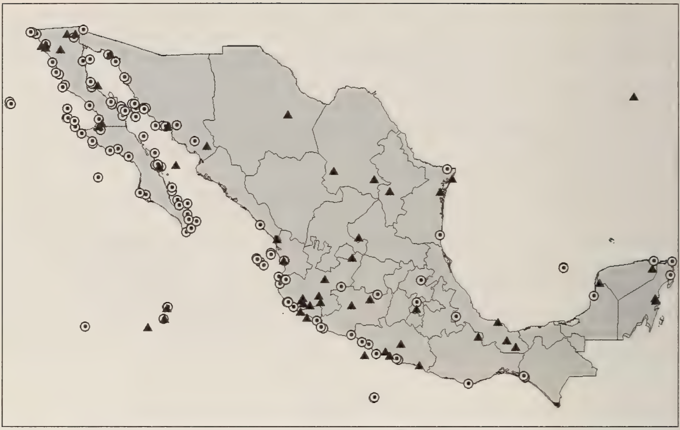

Fig. 4. Comparison of different sources of locality data, for a suite of aquatic birds (Procellariiformes, Gaviiformes and Pelecaniformes). Circles indicate specimen records, whereas triangles indicate visual records from selected literature sources.

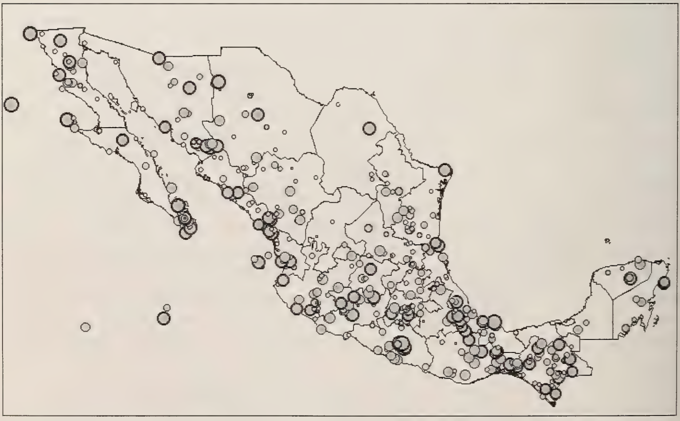

Figure 5. Localities from which more than 100 specimens have been collected, with different sizes of circles indicating increasing numbers of specimens (100 to 4,800).

geographic and ecological information available in digital formats. This analytical format offers a series of opportunities for understanding basic distributional phenomena, particularly with regard to predicting geographic distributions. For example, correlating known occurrence points of species with ecoregions (CONABIO 1999) provides a first idea of potential geographic distributional areas (Fig. 7).

More complex methodologies for estimating distributional areas from occurrence data vary widely (Udvardy 1969), both in approach and in results. Fig. 8 illustrates the application of two different methods to the same dataset for two species (García-Trejo *et al.* 1999). Most methods (e.g. Fig. 8b) depend overmuch on dense point coverage of known distributions for reconstructing areas. Given the paucity of records available for most species (Peterson *et al.* 1998), alternative methods that allow predictions of distributions based on incomplete knowledge are needed.

A powerful tool for extrapolating potential distributional areas from primary point occurrences has been developed by D. R. B. Stockwell (Stockwell & Noble 1992, Stockwell & Peters 1999), and is called the Genetic Algorithm for Rule-set Prediction (GARP). GARP uses an artificial intelligence approach (the genetic algorithm) to produce an abstraction of the ecological niche of a species, based on

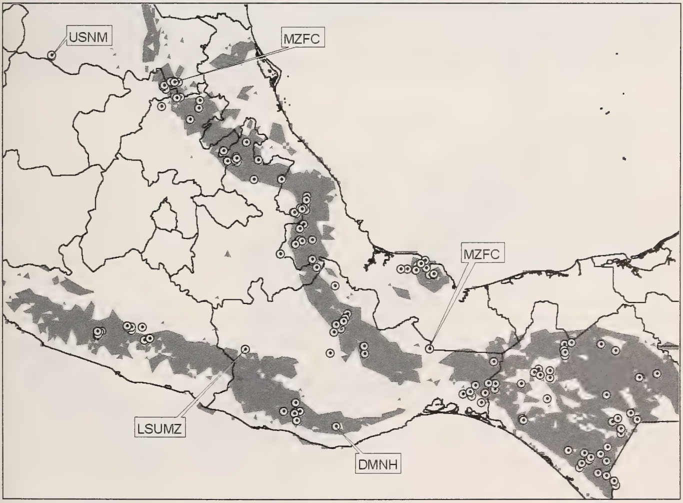

Figure 6. Localities of Common Bush Tanagers *Chlorospingus ophthalmicus* in Mexico. Labels indicate scientific collections in which selected specimens are housed. LSUMZ, Louisiana State University; DMNH, Delaware Museum; MZFC, Museo de Zoología, Facultad de Ciencias UNAM; USNM, United States National Museum. Shading represents the predicted distribution of the species modeled in GARP.

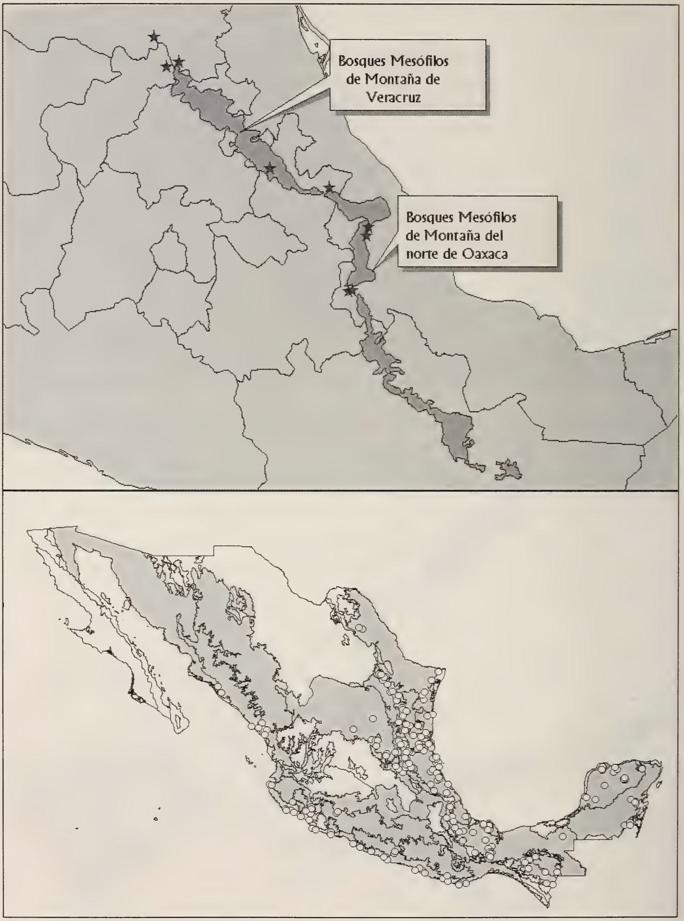
Bosques Mesófilos de Montaña de Veracruz
Bosques Mesófilos de Montaña del norte de Oaxaca

Figure 7. (a) Point locality data (black stars) for the endemic Bearded Wood Partridge *Dendrortyx barbatus* in Mexico, superimposed on a map of terrestrial ecoregions (CONABIO 1999). Areas highlighted are those holding cloud forest or humid pine-oak forest. (b) Map showing the Ecoregions (grey) (CONABIO 1999) in which the Stripe-headed Sparrow *Arremonops rufivirgatus* occurs according to distributional point data (white circles).

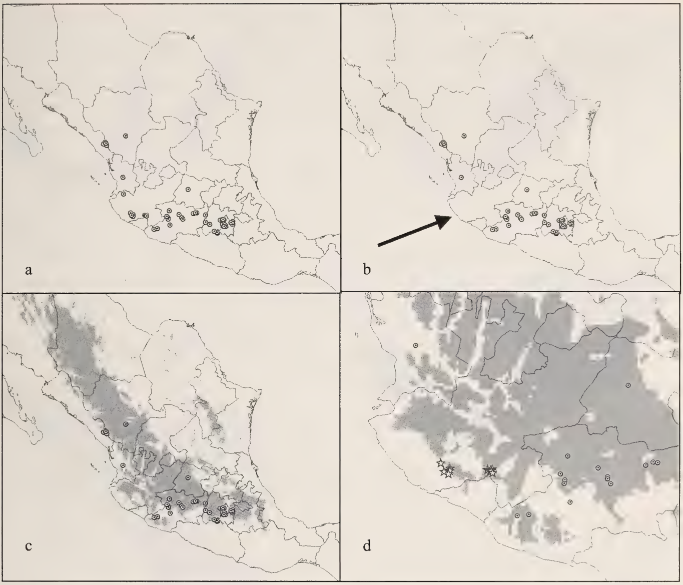

Figure 8. Models of the geographic distribution of an endemic Mexican species, the Stripe-headed Brush-finch *Buarremon virenticeps*: (a) primary point data drawn from the *Atlas* database; (b) removal of test points from the state of Jalisco; (c) GARP prediction of distributional area (predictive model built with data from Jalisco removed); and (d) close-up of state of Jalisco, showing correspondence between prediction and test dataset (stars).

physical and ecological attributes available in digital formats. An example is provided in Fig. 9, in which known occurrences of a species endemic to Mexico (*Buarremon virenticeps*) are used to predict its geographic distribution. Extensive testing of the predictive accuracy of models developed using this approach have amply demonstrated its utility (Peterson & Cohoon 1999, Peterson *et al.* 1999, 2002a,b, Peterson 2001, Peterson & Vieglais 2001, Anderson *et al.* 2002a,b, in press, Feria & Peterson 2002, Stockwell & Peterson 2002a,b).

Species richness, endemism and conservation

There are many potential applications of this information resource and technology to the conservation of biodiversity. For single-species prioritisations, Fig. 10 provides an illustration of the geographic situation of the Oaxaca Sparrow *Aimophila*

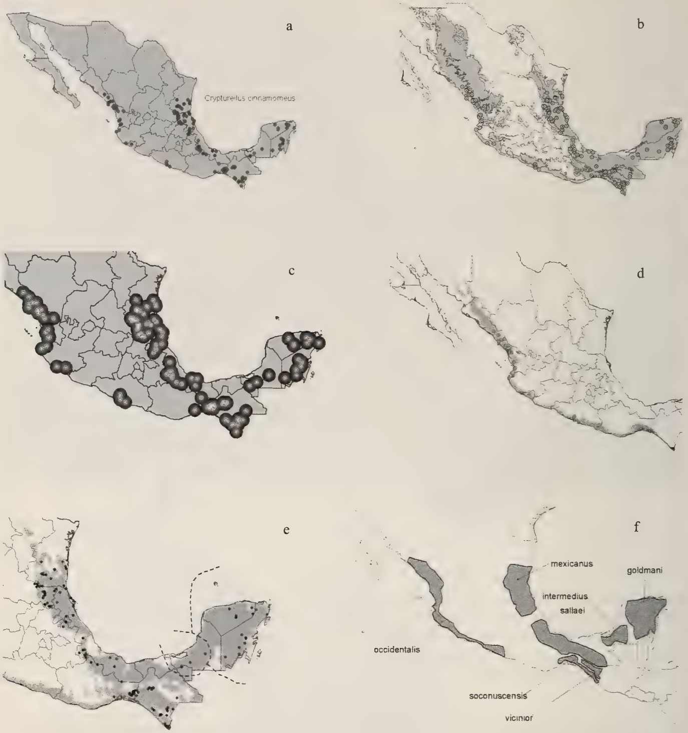
a
Crypturellus cinnamomeus
b
c
d
e
f
mexicanus
goldmani
intermedius
sallaei
occidentalis
soconuscensis
vicinior

Figure 9. Use of primary data points for construction and evaluation of distributional areas: (a) data points for Thicket Tinamou *Crypturellus cinnamomeus*, *sensu* AOU 1998) from the *Atlas* dataset; (b) distribution based on ecoregions highlighted by point data; (c) buffer zones (10 km intervals) for estimating continuity of areas; (d, e) GARP predictions for the two phylogenetic species (*sensu* Navarro & Peterson submitted), Western Tinamou *C. occidentalis* and the eastern populations (*C. mexicanus*); and (f) distributions of northern subspecies (Friedmann *et al.* 1950).

notosticta, a species of conservation concern in Mexico. Indeed, modelling its geographic distribution only amplifies the concern for this species in Mexico, as the species proves to be left out of present conservation efforts entirely.

The predictive approaches of GARP can be applied to more complex challenges, combining results for suites of species. For example, Fig. 11 illustrates an overlay of the distributional areas of quail species endemic to western Mexico. Here, peaks and valleys in richness of endemic species can be detected, and can be incorporated in conservation planning; use of complementarity algorithms permits the development of quantitative conservation strategies (Gordillo-Martínez 2000).

Discussion

The principal source of information on the systematics and distribution of the Mexican avifauna as a whole are Friedmann *et al.* (1950) and Miller *et al.* (1957). Although a recent publication (Howell & Webb 1995) updates the distributional overview, it is in an extended field-guide format and does not provide detailed geographic information for most species. The vast dataset assembled in our work, including

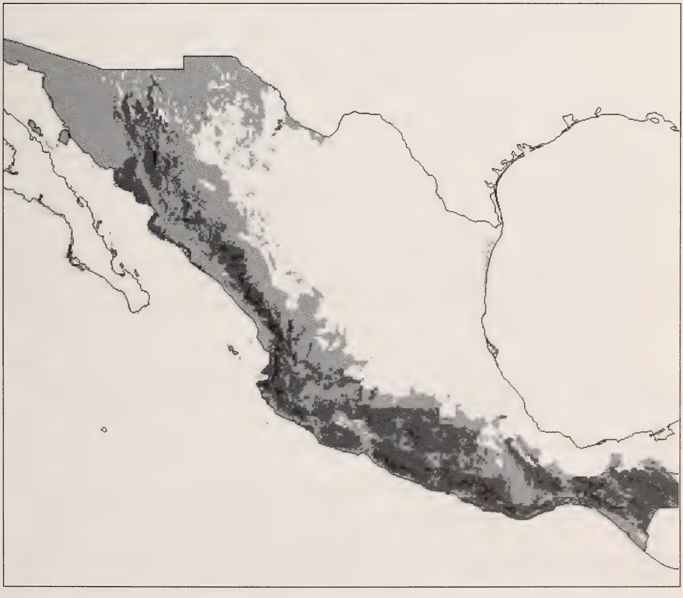

Figure 10. Overlay of potential distributional areas of quail species in western Mexico. Different shades of grey indicate high (black) to low (light grey) concentration of species. Data from Gordillo-Martínez (2000).

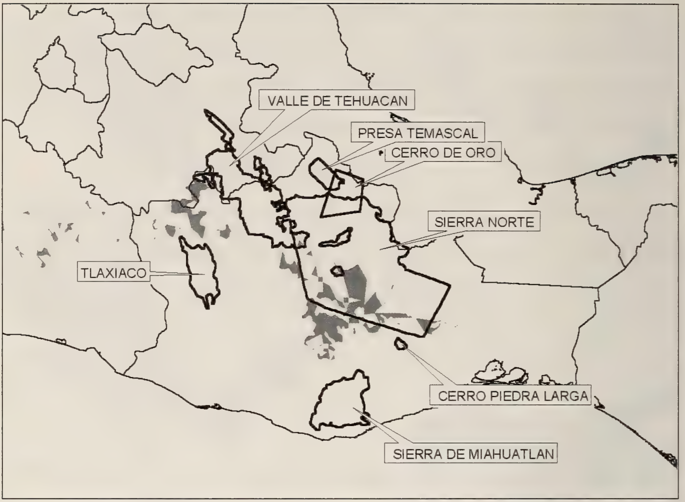

Figure 11. Predicted distributional area (solid grey) of a range-restricted endemic species, the Oaxaca Sparrow *Aimophila notosticta*. Polygons represent Important Bird Areas (IBAs) proposed for the region (Arizmendi & Márquez 2000). Note that only the Valle de Tehuacán Reserve is an area protected officially.

specimens, bibliographic records and some field observational data, forms the basis for our *Atlas of Mexican birds*, currently in preparation in collaboration with specialists around the world. This publication is based on a modern taxonomic treatment of the whole avifauna, and presents detailed analyses of the distribution of each species, as well as summaries of general patterns of species diversity, endemism, conservation status, and correlations with environmental and geographic features of the country. This work will serve as a model of how the bases for national biological surveys can be built from existing information held in the world's natural history museums, and will illustrate the many and varied potential uses of the information.

As one reviewer of this paper stated, 'the value of the kinds of work cited depends on the availability of the (raw) data … Publication of an atlas is all very well, but hard copy data are only marginally more useful than no data at all'. We heartily agree with this point of view. However, electronic 'publication' of the atlas database is neither feasible nor particularly desirable. Problems with feasibility stem from issues of permission to 'serve' data on specimens from a source that is not *at* the institution owning the specimens—several curators are rightly concerned about the implications for their institutions' rights to 'ownership' of data. Moreover, serving such a centralised dataset is not desirable: centralised datasets suffer serious problems with update—as collections databases are edited and corrected at the institutions where specimens are housed, the corrections are not passed on to the centralised data source. Hence, the best solution to the challenge of making these data—and biodiversity data in general—broadly available is not to serve centralised datasets.

A much better solution is that of distributed access to diverse biodiversity datasets. Here, centralisation is only achieved in a virtual sense. Rather, datasets are served by each of the institutions that care for, curate and document the associated specimens, and integrated virtually via the Internet. This design has the great advantage of keeping the data *at the institutions where the specimens are housed.* Three prototype distributed biodiversity networks now serve avian data: *The Species Analyst* (http://speciesanalyst.net), REMIB (http://www.conabio.gob.mx), and ENHSIN (http://www.nhm.ac.uk/science/rco/enhsin). A common technology that should unite these three networks and others is now under development (the 'DIGIR' project). Anticipated is a broad proposal to integrate many additional data sources (the 'ORNIS' [ORNithological Information System] Project!), which is in the process of preparation for submission to the U.S. National Science Foundation for funding.

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The value of the bird collections and associated data in regional museums: *Lanius excubitor* specimens in Šarišské Museum, Bardejov, Slovakia

by Martin Hromada, Lechoław Kuczyński, Maciej Skoracki, Marcin Antczak & Piotr Tryjanowski

Dedicated to the memory of PhMr. Tibor Weisz

SUMMARY

Current ornithology, when working on long-term studies of the ecology and conservation of bird species, faces the problem of how to obtain relevant data. This challenge is particularly acute in the case of rare or uncommon species. The importance of museum collections of all sizes, and aspects of the use of collections for such studies, are the subject of this paper. The Department of Natural History, Šarišské Museum, Bardejov, Slovakia, holds the most extensive collection of Great Grey Shrikes in the world, totalling 665 skin and mount specimens, 600 sterna complexes, 207 ectoparasite samples, 7 endoparasite samples, 132 stomach contents and 9 clutches from north-eastern Slovakia, taken in the period 1956–1983.

Introduction

The Great Grey Shrike *Lanius excubitor,* which has about a quarter of its entire breeding range in Europe, has shown population declines over almost all its European range in recent decades; this trend apparently results from habitat loss through agricultural intensification (Tucker & Heath 1994), and low population densities typify this species in most of Europe (Tryjanowski *et al.* 1999). Obtaining data on long-term trends in the species' population ecology is therefore increasingly problematic. Consequently, most research on the species (e.g. taxonomy, morphology, moult sequences, ecological problems, parasitology) has been based on relatively small sample sizes. Larger datasets are nevertheless available, and occasionally used, for such studies: taxonomy and morphology (Eck 1973, 1990a,b, 1994), ecology and behaviour (Schön 1994a,b), and foraging and nesting biology (Lorek *et al.* 2000).

One solution to the current situation of scarcity of relevant field data is the use of museum collections, where much relevant information awaits a number of novel applications, in spite of the fact that the use of museum collections as an information source is rather uncommon (Remsen 1995). Traditional bird collections generally include study skins, spirit specimens, skeletons, nests, clutches of eggs, frozen tissues, parasites and stomach contents (Mearns & Mearns 1998). Data on locality, date, collector and measurements are generally associated with specimens, although more detailed information, including circumstances of collection, habitat, behaviour, additional measurements, and condition of the bird, are less commonly included on labels. The importance of maximising information content related to specimens was recently emphasised in the metadata concept in ecology and biology (Michener 1994).

Most museum-based studies have been carried out in large, well-known collections (Peterson *et al.* 1998). Owing to exigencies of time and resources, most researchers focus studies in larger collections rather than regional museums; but we submit that the latter also often hold useful high-quality data. The aim of this paper is to outline uses of series of Great Grey Shrikes in the Šarišské Museum, Bardejov (SMB), Slovakia, which holds what we believe to be the world's largest sample of this species.

Materials and methods

Study area

An important feature of the SMB collection is its orientation toward significant series from a single geographic area. From 1957 to 1983, Great Grey Shrikes were collected in north-eastern Slovakia (49°03´–49°27´N, 20°30´–21°47´E) in the eastern and western Carpathians, in the European temperate zone. This region, centered around Bardejov, is hilly, with elevations from 170 m in the lowest river basins to 1,157 m at the peaks of the Èergov Mountains.

Owing to its climatic and landscape features, this region mixes Mediterranean (e.g. Bee-eater *Merops orientalis*) and boreal faunistic elements (e.g. Tengmalm´s Owl *Aegolius funereus*, Pygmy Owl *Glaucidium passerinum*). Broad valleys running approximately north–south provide corridors for fauna and flora from the warm open plains of the Carpathian Basin and Great Pannonian Lowland. The region is intensively farmed but presents a mosaic of agricultural fields in lower parts, forests along creeks and rivers, and continuous forests on hilltops and mountainsides.

Collector

PhMr. Tibor Weisz (1928–1983), pharmacist, zoologist and phenomenal collector, dealt with many animal groups, as is seen in the diversity of his specimen material. He collected for the Hungarian Natural History Museum, Budapest (specimens destroyed), and the Museum of the University of Forestry and Wood Industry, Košice, Slovakia. He was founder of two natural history museums, in Prešov and Bardejov, both in Slovakia. The natural history collection at Bardejov alone holds about 700,000 specimens, including nearly 6,000 skins of almost 700 bird species, more than 3,500 sterna, approximately 800 clutches of eggs, etc.; Weisz's principal interests were with birds.

Documentation of birds in SMB

The main distinguishing feature of the SMB museum, established in 1956, lies in the way the collections were documented. The data associated with most specimens include much more in the way of measurements and notes than in other museums, including information on length of both wings, condition (general health), size of gonads, relationships with other individuals (parent, nestling, sibling), and other associated voucher material (sternum, stomach content, ecto- and endoparasites, clutches, nests). An important component of data in the collection consists of detailed notes on all activities of a collector during the day, notes on each collecting event, and often cross-reference between specimens. Weisz was a pioneer of modern ornithological and natural history methods in museum collections in Slovakia and the Czech Republic. However, maybe because he was the only naturalist in the museum for 20 years, and maybe because of his heavy preoccupation in fieldwork, a small part of his collections lack one or more basic items of information, such as locality, sex, etc. Moreover, the collector's personal diaries, which contain detailed descriptions of his daily activities, remain in the possession of his family, and are accessible only with their permission.

Specimen collection

Many local shooters under the direction of Tibor Weisz collected the SMB Great Grey Shrike series. All preparation steps were noted, and all specimens labelled with a unique numeric identifier. Field notes included information on each bird collected, frequently including habitat descriptions, behavioural observations, etc. The birds were collected through the entire year, during single day trips or longer expeditions, using cars or all-terrain vehicles to cover broader areas. The taxidermists were members of a field team, so preparation and data collection were done immediately, or shortly after obtaining the specimens.

Specimen preparation and processing

Specimens were prepared by means of traditional techniques for making study skins. Arsenic was used as a preserving medium. Skilled taxidermists J. Trencsenyi, V. Borùvka, and S. Trenèan were the principal preparators of the SMB bird collection. All measurements were taken by T. Weisz on fresh birds, with body mass sometimes noted by taxidermists. Measurements taken on most or all specimens were body length, lengths of both wings (slightly flattened), lengths of longest and shortest rectrices, tarsus length (measured as the distance between the sole side of the opened foot, abutted on callipers at right angle and measured to the proximal point of the tarsometatarsus), bill length measured to the anterior edge of the nostril and to first feathering, and wing span. Sex was determined through dissection of gonads, and age was noted, as well as description of colouration, wing-bars and other features.

Ectoparasites were collected by T. Weisz or the taxidermists from fresh birds by direct inspection, without using special methods such as fumigation. Parasites were preserved in 75% ethanol. Dissection out of endoparasites, when done, was undertaken directly in the field by J. K. Macko (Parasitological Institute, SAS, Kosice, Slovakia) and his co-workers. Material was preserved in fixative solutions specific to particular helminth groups (e.g. nematodes in Barbagal solution, cestodes in alcohol-formol-acetic acid). Stomach contents were collected and preserved in the course of preparation, and stored in 70% ethanol, sometimes inside the actual stomach.

Sterna were preserved during preparation, and cleared with hydrogen peroxide; complete sternal preparations include the sternum proper, furcula, coracoids and scapulas.

The collection database is built on information recorded at several levels. The collector's first step was to note data in a field notebook. All of the following information resources, such as cards and the database, are based on these notebooks.

Basic evidence on specimen acquisition

The Great Grey Shrike series was established in the course of other research and collecting activities of the Department of Natural History of SMB. Members of the collecting teams report no special preference for this species. We present the spatio-temporal origin of samples on a seasonal and year-to-year basis (Fig. 1, 2). Table 1 outlines the data limitations on the specimen material relating to the sample in SMB.

The collection shows two peaks, i.e. in the early sixties and in the early seventies. This gives an opportunity to stratify data into two groups and still have enough data for statistical treatment, when e.g. splitting the samples around 1970.

Month of collection reveals seasonal variation in sampling. The peak in March doubtless reflects the period with the highest probability of seeing birds. November probably reflects the month in which the birds arrive in their winter territories. Both peaks correspond with times of migration.

TABLE 1

Features of the Great Grey Shrike series in the SMB collection

	N	%
Total number of specimens	665	100
Number lacking date	41	6
Number lacking locality information	57	9
Number not aged	123	18
Number not sexed	146	22
Number with obvious measurement errors	16	2
Number of ectoparasite samples	207	31
Number of endoparasite samples	7	1
Number of stomach contents sampled	132	20
Number of sterna	600	90
Number of egg clutches	9	100
Number of clutches with known paternity	5	56

Taxonomic status of birds in the collection

The area sampled is situated at the southern edge of the continuous geographic breeding range of the Great Grey Shrike. All the birds in SMB are currently identified as *Lanius excubitor excubitor*, the nominate race (T. Weisz in Hudec 1983, Eck 1993, 1994), although several individuals appear to reflect characters of the south-eastern subspecies *L. e. homeyeri*; the question has yet to be examined in detail.

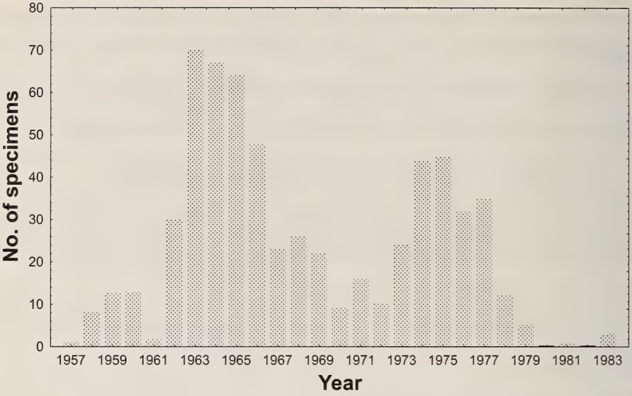

Fig. 1. Annual additions of Great Grey Shrikes to the SMB collection

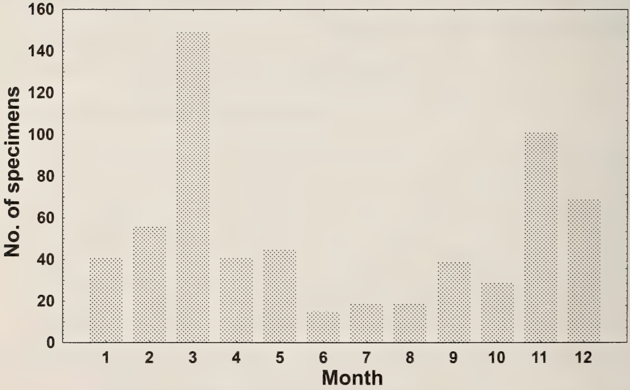

Fig. 2. Specimens of Great Grey Shrikes in SMB, by month of collection

Stomach contents

The 132 stomach content samples contained 608 prey items belonging to 82 animals of 39 families and 17 orders (Hromada & Krištín 1996). Only small mammals, and to a lesser degree carabid beetles, were found in food relatively regularly throughout the year. Diversity of food items was highest in May and June, while evenness peaked in January and February. Hromada & Krištín (1996) discussed the occurrence of necrophagous animals and difficulties with small prey items, as well as methodological difficulties in estimating diets from stomach contents.

Parasites

At the time of collection, the birds were investigated for ectoparasites and a subset also for endoparasites. In current research one secondary was examined to estimate rates of infestation by syringophilid mites living in the feather quill, and a new species, *Syringophiloidus weiszii*, was identified (Skoracki *et al.* 2001). In total, 508 Great Grey Shrikes were examined, of which 18 (3.54%) were infested by quill mites. This low rate is probably due to the solitary nature of the shrikes and thus low dispersal opportunities of these highly specific parasites (Skoracki *et al.* 2002).

Time series

The sample allows us to address temporal issues in two ways: (1) changes across the entire period (26 years), and (2) within-year seasonal changes. An extended time series helps avoid the biases that can plague shorter studies. Data can be integrated with new datasets obtained by non-invasive methods, e.g. from blood, feather and parasite sampling, etc. Temporally extended series can be used to evaluate the effects of increasing human population and environmental damage. Data from the collection enabled us to estimate a minimum density of Great Grey Shrikes in around Bardejov in the 1960s (Krištín & Hromada 2002): breeding density at that time was at least twice as high as it is at present.

Discussion

The role of regional museums is of growing importance at present. In spite of their smaller overall holdings, regional museums often have the advantage of local expertise, ability to respond quickly to local issues and collect significant conservation data. Because collecting localities are often nearby, and staff are usually experts regionally, a main focus is often on local community composition and conservation issues (Davies 1995, 1996). Thus, regional museums should play a crucial role in the long-term collecting related to questions of regional conservation, natural history, species composition, and community change. This focus of local expertise can offer great advantages, particularly when work is developed in connection with major museum collections that can provide expensive analytical capabilities and broader contextual information for local faunas and floras.

The long-term maintenance of systematic collections, including smaller ones, serves the important task of documenting the biodiversity of the earth (Backeljau *et al.* 1995, Goethem *et al.* 1995, Shaffer *et al.* 1998). Use of this information resource for studying diverse aspects of ecology, environmental biology and conservation is relatively uncommon, in spite of the great potential that we have attempted to illustrate in this paper. Local and regional collections are, however, more vulnerable to loss, given shifts in availability of economic resources and political upheavals.

The best way to realise the potential of these information resources is via co-operation. Indeed, a recent commentary stated: 'We find a picture of what the new natural history museum world should look like: it will be collaborative....' (Apt *et al.* 1997). Networking and participating in internet-based data-sharing projects are one avenue to pursue in this regard (Peterson *et al.* 1998).

The collections of SMB, despite the good use made of the Great Grey Shrike material, are still relatively under-utilised. The principal problem is probably that SMB has not yet issued its catalogue, so the collection remains relatively unknown. Nevertheless, the preliminary results of our analysis of the extensive SMB Great Grey Shrike series indicate exciting opportunities for more advanced studies, e.g. ptilochronology, dynamics of infestation by parasites through season and time periods, effect of population dynamics on evolution and genetics, physiological trade-offs, etc.

These examples illustrate the importance of broad-spectrum preservation of information content by collectors. Almost none of the methods we are presently using had been developed in the 1950s, when the SMB series was begun. Generally, most information available can be used in the future in ways not currently appreciated. Although the usual pressures exist for efficiency in work effort, it is impossible to predict what may be useful in future studies (see, e.g., Remsen 1995). Today we are reaping the rewards of the work of our predecessors, the collectors from decades or more in the past, and we have to attempt to be equally shrewd and responsible with respect to those that come after us.

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Specimens of extinct and threatened birds in the collections of the National Museum of Natural History in Sofia, Bulgaria

by Zlatozar Boev

Introduction

Over the last five decades a series of specimen catalogues of extinct and rare birds in museum collections has been published. For Europe, such papers were made available by the natural history museums in, e.g., Berlin (Stresemann 1954), Frankfurt am Main (Mertens & Steinbacher 1955), Paris (Jouanin 1962), Exeter (Howes 1969), Dresden (Eck 1970), Cambridge (Benson 1972), Moscow (Neufeldt 1978, Tomkovich & Barisheva 1987), Liverpool (Fisher 1981), Milan, Genoa and Florence (Violani *et al.* 1984), Saint Petersburg (Sokolov & Il'yashenko 1987), Tring (Knox & Walters 1994), and Lviv (Tsaryk 2000). Surveys of this kind are useful to outline the whereabouts of rarities collected in the past throughout the world (Williams 1960). Here such a catalogue is presented for the National Museum of Natural History in Sofia (NMNHS) in Bulgaria.

The NMNHS was founded in 1889 by King Ferdinand I of Bulgaria. Its bird collections were gradually built up by regular acquisition of local birds and zoo specimens. Also, some larger collections were obtained, notably those of Amede Alleon (1838–1904) from south-east Europe (including *c.*900 mounted specimens), Emil Holub (1847–1903) from South Africa (*c.*300 mounted specimens), E. C. Stuart Baker (1864–1944) from India and South-east Asia (152 mounted specimens), and Pavel Patev (1889–1950) from Bulgaria (over 9,000 specimens, mostly preserved as study skins) (Boev 1991). The oldest bird in the collection is an adult male Channel-billed Toucan *Ramphastos vitellinus* shot in Brazil in 1860. At present, the collection holds over 12,000 registered skins and mounts of birds, plus over 1,300 partial or complete avian skeletons (Boev 1993). Some pre-1950 mounts are also present but are not yet catalogued.

A catalogue of the bird collections of NMNHS was published over 90 years ago (Anon. 1907). At the time this was a complete inventory, but considerable changes have since occurred, largely owing to important acquisitions, but also because a part of the collection was lost to fire in March 1944. Recent overviews of the bird contents of NMNHS involved only parts of the collection, e.g. catalogues of all parrots Psittaciformes (Boev 1990) and of the Stuart Baker material (Boev 1997a).

The present list provides data on the specimens of those species in NMNHS listed in BirdLife International (1999) and on Appendix I of the Convention on International Trade in Endangered Species (CITES) (species listed on this appendix are not necessarily threatened in the formal sense, but are regarded as highly vulnerable to international trade and thus have the equivalence of a threatened species under international law). All specimens are prepared as mounted birds or study skins.

Material and methods

Systematics, and categories of the conservation status and CITES listing, follow del Hoyo *et al.* (1992, 1994, 1996, 1997, 1999, 2000, 2002), with updated conservation status based on BirdLife International (2000) (where species have been downlisted since the completion of this review in 1999, this is noted but the entry is retained). To facilitate comparison of species and the location of collecting site, modernised species names and locality names are used (rather than those attaching to the specimen itself), the latter according the most recent *Times atlas* or (when not in the latter) with an indication of the nearest larger city. Square brackets around place names indicate either (a) the former name of the locality as given on the original specimen label, or (b) a known origin (e.g. New Zealand) or a known local provenance (e.g. a zoo) of the specimen in the absence of other data, or (c) extra information that helps fix the given locality.

Each entry begins with the catalogue number. Ad = Adult, Juv = Juvenile, Subad = Subadult. 'Sofía Zoo' is the Royal Zoological Gardens, Sofía. N = northern, S = southern, E = eastern, W = western, C = central. Coll. = collected by; don. = donated by.

In cases where specimens were in sufficiently good condition, (usually) six standard measurements were taken: L = body length from the tip of the upper mandible to the tip of the longest tail feathers (uppertail-coverts in males of *Pavo*); A = wing length from the ulnar-carpometacarpal joint to the tip of the longest primary feather; C = tail length from the pygostyle (or pygostyle area) to the tip of the longest tail feathers; R = bill length (culmen length) from the middle of the front edge of the cere to the tip of the upper jaw, i.e. the bare horny part; T = tarsus length from the joint between the third toe and the tarsometatarsal bone to the tibiotarsal-tarsometatarsal joint, measured on the frontal surface; D = third toe length with the claw from the proximal joint of the first phalanx of the third toe to the tip of the claw. The measurements were taken in millimetres with calipers and a thin metric ruler.

List of species

APTERYGIDAE

Little Spotted Kiwi *Apteryx owenii*. Vulnerable. One:

- 525 Ad [New Zealand]. L 505, A –, C –, R 64.8, T 49, D 50.6.

SPHENISCIDAE

Jackass Penguin *Spheniscus demersus*. Vulnerable. Three, all from zoos:

- 195 Ad, bought alive on 29 May 1936 in Hamburg, died in Sofia Zoo on 10 April 1937. L 600, A 165, C 60, R 55.5, T 35, D 71.
- 196 Subad female [Plovdiv Zoo].
- 223 Ad male, died in Sofia Zoo in May 1974. L 635, A 196, C 65, R 66.7, T 48, D 87.3.

PELECANIDAE

Dalmatian Pelican *Pelecanus crispus*. Conservation Dependent. CITES I. Three:

- 278 Ad, no further data. L 1,710, A 690, C 300, R 380, T 111, D 128.
- 279 Juv, 26 May 1956, Srebarna Lake near Silistra (N Bulgaria), coll. M. Daneva.
- 280 Ad female, 30 March 1904, Negovan Lake near Sofia (W Bulgaria).

PHALACROCORACIDAE

Pygmy Cormorant *Phalacrocorax pygmeus*. Insufficiently Known (now Near Threatened). Eight:

- 2483 Ad, no further data. Bulgaria.
- 2484 Unsexed, 14 October 1908, Vranya near Sofia (W Bulgaria).
- 2485 Unsexed, 27 October 1896, Plovdiv (S-C Bulgaria).
- 2486 Ad male, 4 May 1904, Iskür River near Sofia (W Bulgaria).
- 2487 Ad male, 6 December 1896, Yarem-Bourgas (near Istanbul, Turkey), coll. A. Alleon. L 540, A 220, C 148, R 31.9, T 29.7, D 50.7.
- 2488 Ad male, 5 September 1898, Iskür River.
- 2489 Ad male, 27 November 1892, Yarem-Bourgas, coll. A. Alleon. L 560, A 208, C 165, R 28.7, T 36, D 57.5.
- 5183 Subad, January 1995, Durankulak Lake (NE Bulgaria). L 570, A 210, C 152, R 28.7, T 37, D 60.

THRESKIORNITHIDAE

Northern Bald Ibis *Geronticus eremita*. Critically Endangered. CITES I. Two, both from Sofia Zoo and probably originating from one of the Syrian colonies:

- 2147 Ad male, died 16 July 1911. L 724, A 363, C 224, R 137.2, T 71.5, D 65.3.
- 2148 Ad female, died 30 August 1911. L 705, A 367, C 173, R 136.8, T 68, D 63.9.

ANATIDAE

Lesser White-fronted Goose *Anser erythropus*. Vulnerable. Two:

- 106 Ad female, 22 March 1902, Negovan Marsh near Sofia (W Bulgaria), coll. L. Siklunov. L 530, A 373, C 123, R 29.6, T 53, D 58.3.
- 4624 Ad male, 15 March 1932, Musachevo [near Sofia], coll. V. Damyanov.

Red-breasted Goose *Branta ruficollis*. Vulnerable. Two:

- 5238 Ad male, January 1997, Durankulak Lake (NE Bulgaria), coll. P. Dimitrov. L 625, A 368, C 128, R 24.5, T 52, D 52.7.
- 5170 Ad, December 1993, Durankulak Lake, coll. P. Dimitrov.

Ferruginous Duck *Aythya nyroca*. Vulnerable (in Collar *et al.* 1994), now Near Threatened. One:

- 2680 Ad male, 10 January 1896, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon. L –, A 189, C 90, R 43.6, T 32.1, D 57.2.

White-headed Duck *Oxyura leucocephala*. Endangered. Thirteen:

- 73 Juv, no further data.
- 78, 79 & 2717 Male, female, and male, 9 March 1890, Burgas (E Bulgaria).

- 80 Unsexed, 1893, Pazardzhik (S-C Bulgaria).
- 2710 No data.
- 2711 Ad female, March 1882, Constanta (E Romania), coll. A. Alleon.
- 2712 & 2714 Females, 'Mediterranean', coll. A. Alleon.
- 2713 & 2715 Juv and ad male, April 1883, Constanta, coll. A. Alleon.
- 2716 Female, 'Mediterranean', coll. A. Alleon. L 427, A 60, C 82, R 41.7, T 43.0, D 65.
- 5154 15 January 1993, Poda near Burgas, coll. P. Dimitrov.

CATHARTIDAE

Californian Condor *Gymnogyps californianus*. Critically Endangered. CITES I. Two:

- 687 Ad female, 10 June 1902, Arroyo Grande (California, USA), coll. Arthur Wilcox.
- [without catalogue number] Ad male. L 1,260, A 818, C 465, R 39, T 129, D 145.

Andean Condor *Vultur gryphus*. CITES I. One:

- 688 Ad male. L 1,315, A 835, C 375, R 44, T 127, D 152.

ACCIPITRIDAE

Cinereous (Black) Vulture *Aegypius monachus*. Vulnerable (now Near Threatened). Four:

- 699 Ad, no further data. L 1,122, A 825, C 389, R 62, T 135, D 108.
- 700 Ad male, January 1893, Istanbul (Turkey), coll. A. Alleon.
- 2940 Juv, May 1881, Dobrogea (E Romania), coll. A. Alleon.
- 2946 Juv, December 1892, Istanbul, coll. A. Alleon.

White-tailed Sea Eagle *Haliaeetus albicilla*. Vulnerable (now Near Threatened). CITES I. Eight:

- 506 Ad female, 29 January 1897, Demirci (20 km N of C Istanbul, Turkey), coll. A. Alleon.
- 507 Juv female, Burgas, died in Sofia Zoo 2 February 1897.
- 508 Ad male, died in Sofia Zoo 17 August 1893. L 820, A 520, C 250, R 51.8, T 90, D 120.
- 2920 Juv male, 7 December 1898, no locality, coll. A. Alleon.
- 2921 Ad male, 11 February 1894, San Stefano (15km WSW of C Istanbul, Turkey), coll A. Alleon. L 940, A 608, C 291, R 53.0, T 93, D 102.
- 2934 Ad female, 29 January 1899, Demirciköy (20 km N of C Istanbul, Turkey), coll. A. Alleon.
- 2935 Ad male, 23 December 1894, Demirciköy (as above), coll. A. Alleon.
- 2936 Juv, 7 November 1898, Demirciköy (as above), coll. A. Alleon.

Imperial Eagle *Aquila heliaca*. Vulnerable. CITES I. Thirty-nine:

- 500 Ad, 21 October 1890, Bulgaria.
- 501 Ad female, no further data.
- 504 Juv, 12 June 1916, Vranya near Sofia (W Bulgaria).

- 505 Juv, 18 November 1930, Sgledintsi near Sofia.
- 2837 Juv, June 1882, Rumelia [former region, = S Bulgaria].
- 2838 Juv male, 3 June 1902, Sofia.
- 2848 Ad, 19 October 1898, 'Sent George' [untraced; no further data].
- 2849 Ad female, 16 March 1894, Bosporus (Turkey), coll. A. Alleon. L 855, A 612; C 312, R 44.5, T 91, D 96.
- 2850 Ad, Bulgaria. L 950, A 640, C 303, R 44,5, T 100, D 110.
- 2851 Juv male, 28 March 1899, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon. L 850, A 597, C 305, R 41.4, T 90, D 93.
- 2813 Ad female, 20 April 1893, Yarem-Bourgas (near Istanbul, Turkey), coll. A. Alleon. L 883, A 626, C 293, R 41.8, T 93, D 100.
- 2910 Ad, 2 December 1892, Tsaribrod (= Dimitrovgrad in present-day Yugoslavia).
- 2918 Juv female, 3 March 1898, Makriköy (see above), coll. A. Alleon.
- 2931 & 2932 Juvs, no further data.
- 4773 Unsexed, 30 January 1895, Tarnovo-Seymen [now Simeonovgrad, SE Bulgaria], coll. Starikov.
- 4774 Juv male, died Sofia Zoo 5 July 1903.
- 4775 Juv female, 11 March 1904, Krichim (SW Bulgaria).
- 4776 & 4777 Ad and juv, Bulgaria.
- 4778 Juv female, 25 July 1894, Bulgaria.
- 4779 & 4783 Juv female and juv male, 17 February 1902, Sofia.
- 4780 Ad female, 9 February 1902, Sofia.
- 4781 Ad female, 15 September 1894, Pancharevo (Bulgaria).
- 4782 Juv female, 1 April [year unspecified], Sofia.
- 4784 Juv, 1896, Plovdiv (S-C Bulgaria).
- 4785 Unsexed, 10 October 1911, Sofia.
- 4786 Juv male, died in Sofia Zoo on 12 April 1885.
- 4787 Juv male, 17 November 1906, Sofia.
- 4788 Juv male, 27 September 1893, Belitsa (SW Bulgaria).
- 4789 Ad male, 9 February 1895, Tarnovo [now Veliko Tarnovo, CN Bulgaria].
- 4790 Ad male, 12 June 1911, Sofia.
- 4791 & 4793 Juvs, 18 and 17 February 1929, Euxinograd [near Varna, NE Bulgaria].
- 4792 & 4794 Ad female and ad unsexed, 7 May 1898, Plovdiv.
- 4795 Ad male, 16 February 1917, Pleven district (N Bulgaria).

Greater Spotted Eagle *Aquila clanga*. Vulnerable. Thirteen:

- 493 Ad female, 15 November 1932, Burgas (E Bulgaria), coll. V. Yulius. L 695, A 517, C 280, R 34, T 100, D 90.
- 494 Juv female, 8 July 1904, Sofia (W Bulgaria).
- 495 Ad male, 24 April 1895, Plovdiv (S-C Bulgaria).
- 2925 Ad male, 21 April 1890, Banya near Kostenets (SW Bulgaria).

- 2926 Juv male, September 1899, Marmara (an island in the Sea of Marmara, Turkey), coll. A. Alleon.
- 2927 Ad male, 7 May 1894, Bosporus (Turkey), coll. A. Alleon. L 735, A 564, C 290, R 36.4, T 90, D 83.
- 2929 Juv, June 1882, Dobrogea (E Romania), coll. A. Alleon.
- 4759 Ad male, 17 June 1911, Krichim (SW Bulgaria).
- 4760 & 4761 Ad females, 11 April 1918 and 27 May 1907, Krichim.
- 4762 Ad female, 28 March 1894, Kumanitsa near Sofia (W Bulgaria).
- 4772 Unsexed, 1 August 1947, Samokov (SW Bulgaria).
- 5091 Ad male, died in Sofia Zoo in February 1984, coll. A. Prostov.

FALCONIDAE

Lesser Kestrel *Falco naumanni*. Vulnerable. Fifteen:

- 486 Ad female, Bulgaria. L 355, A 250, C 155, R 14.1, T 31, D 40.
- 487 Ad male, Plovdiv (S-C Bulgaria).
- 3059 Juv male, 26 August 1894, no locality, coll. A. Alleon.
- 3060 & 3061 Ad males, 30 March 1899 and 22 April 1895, San Stefano (15km WSW of C Istanbul, Turkey), coll. A. Alleon.
- 3062 Ad male, Bulgaria.
- 3063 Ad female, 4 August 1919, Krichim (SW Bulgaria).
- 3064 Ad female, 29 April 1890, Plovdiv (S-C Bulgaria), coll. A. Alleon.
- 3065 & 3067 Ad female and ad male, 4 April 1890, Plovdiv, coll. A. Alleon.
- 3066 Juv female, 28 September 1895, Demirci (20 km N of C Istanbul, Turkey), coll. A. Alleon.
- 3068 Juv female, 20 August 1894, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon. L 323, A 223, C 144, R 12.7, T 26.4, D 30.
- 3069 Ad female, April 1892, Makriköy (as above), coll. A. Alleon.
- 3070 & 3071 Unsexed juvs, June 1892, Rumelia (former region, = S Bulgaria), coll. A. Alleon.

Peregrine Falcon *Falco peregrinus*. CITES I. Eleven:

- 463 Ad male, 14 January 1894, Çekmece (20 km W of Istanbul, Turkey), coll. A. Alleon.
- 464, 3111 & 3117 Juv female and two juv males, 14 November 1898, 23 October 1898, and 8 October 1893, respectively, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon.)
- 3109 Juv female, 6 December 1897, Çekmece (see above), coll. A. Alleon. L 430, A 370, C 205, R 22.2, T 47.5, D 80.
- 3110 Ad male, 2 October 1897, Demirci (20 km N of C Istanbul, Turkey), coll. A. Alleon. L 465, A 318, C 170, R 19.5, T 40.7, D 69.
- 3112 Juv female, 11 August 1893, Bulgaria.
- 3113 Ad female, January 1893, Makriköy (see above), coll. A. Alleon.
- 3115 Ad male, 12 March 1901, Plovdiv (S-C Bulgaria).
- 3118 Ad female, Bulgaria.

- 3121 Ad female, 14 January 1899, Makriköy (see above), coll. A. Alleon. L 440, A 378, C 178, R 23.4, T 46, D 79.

CRACIDAE

Alagoas Curassow *Mitu mitu*. Critically Endangered. CITES I. One:

- 620 Unsexed, received alive in Sofia Zoo on 20 May 1924 and died 9 February 1938. This specimen shows most but not all the characters of *Mitu mitu* as opposed to Razor-billed Curassow *M. tuberosa*. L 900, C 330, T 120, A 398, R (tip to gape) 59.6, (tip to forehead over culmen) 66 (Boev 1997b).

PHASIANIDAE

Cabot's Tragopan *Tragopan caboti*. Vulnerable. Two, both from Sofia Zoo:

- 607 Ad male, died 6 February 1898. L 500, A 242, C 200, R 21.4, T –, D 87.
- 3954 Ad male, died 7 February 1898.

Himalayan Monal *Lophophorus impejanus*. CITES I. Eight, all from Sofia Zoo:

- 621 Female, died 5 September 1897. L 600, A 285, C 188, R 34.5, T 60, D 64.
- 622 Juv female, died 3 September 1900.
- 623 Male, died 14 February 1906. L 652, A 288, C 196, R 42.2, T 69, D 69.7.
- 3890 & 3891 Ad males, died 6 October 1900 and 24 November 1901.
- 3894 Juv male, died 11 September 1897.
- 3892 & 3895 Ad male and ad female.

Siamese Fireback *Lophura diardi*. Vulnerable (now Near Threatened). Two, both from Sofia Zoo:

- 626 Ad male, died 10 April 1903. L 690, A 251, C 370, R 28.3, T 87, D 49.3.
- 627 Ad female, died 31 March 1899. L 520, A 220, C 220, R 26.1, T 75.0, D 42.

Crested Fireback *Lophura ignita*. Vulnerable (now Near Threatened). Four, all from Sofia Zoo:

- 609 Ad male, ssp. *rufa*, died 25 November 1898. L 670, A 295, C 260, R 34.4, T 109, D 58.6.
- 610 Ad female, ssp. *rufa*, died 4 November 1897. L 490, A 225, C 174, R 25.9, T 74, D 39.5.
- 651 Ad male, ssp. *nobilis*, died 17 October 1899. L 640, A 300, C 270, R 30, T 112, D 67.2.
- 653 Ad female, ssp. *nobilis*, died 27 January 1903. L 535, A 290, C 198, R 25, T 74, D 55.

Swinhoe's Pheasant *Lophura swinhoei*. Vulnerable (now Near Threatened). CITES I. Eight, all from Sofia Zoo:

- 614 Ad male, died 21 February 1899. L 592, A 272, C 241, R 31.4, T 81, D 60.6.
- 615 Juv female, died 1 September 1901.
- 616 Ad female, died 31 March 1908. L 550, A 242, C 250, R 24.5, T 73, D 52.
- 619 No data

- 3791, 3809, 3810, 3783 Juv males, died 15 April 1898, 12 August 1901, 6 November 1899, and 18 August 1900, respectively.

Reeves's Pheasant *Syrmaticus reevesii*. Vulnerable. Thirteen, many of these from a feral population living in the woods near Krichim (SW Bulgaria, near Plovdiv):

- 595 Ad male, Krichim, 4 March 1920, shot by H M Tsar Boris III. L 1,980, A 290, C 1,610, R 31.2, T 88, D 65.4.
- 597 Ad female, 24 January 1912 [Krichim]. L 730, A 232, C 383, R 25.4, T 57, D 55.8.
- 2183 Ad male, 27 October 1909, Krichim, coll. H M Boris III.
- 2484 Ad female, 27 January 1912 [Krichim].
- 2185, 2187 & 2188 Ad males, 3 November 1914, 23 January 1914, and 17 November 1917 [Krichim].
- 2186 Ad male, 27 January 1914 [Krichim], coll. Princess Nadezhda.
- 2189, 2190 & 5189 Ad males, died in Sofia Zoo 10 October 1899, 18 June 1898 and 20 October 1994.
- 4000 Ad female, no further data.
- 4014 Ad female, died in Sofia Zoo 15 June 1898.

Elliot's Pheasant *Syrmaticus ellioti*. Vulnerable. CITES I. Five, all from Sofia Zoo:

- 601 Ad male, died 10 November 1899. L 760, A 236, C 432, R 29.9, T 67, D 55.3.
- 602 Ad female, died 9 May 1899. L 440, A 210, C 177, R 23, T 60, D 48.4.
- 3960 & 3965 Ad males, died 26 January 1897 and 29 October 1897.
- 3964 Ad female, died 21 March 1901.

Brown Eared-pheasant *Crossoptilon mantchuricum*. Vulnerable. CITES I. Three, all from Sofia Zoo:

- 650 Ad male, died March 1901. L 940, A 310, C 520, R 32.2, T 105, D 73.5.
- 3927 No data.
- 3972 Ad male, died 19 March 1901.

Cheer Pheasant *Catreus wallichii*. Vulnerable. CITES I. Two, both from Sofia Zoo:

- 612 Ad female, died 26 July 1899. L 762, A 230, C 445, R 21, T 75, D 51.8.
- 613 Ad male, died 30 November 1904. L 918, A 255, C 557, R 29.3, T 68, D 61.5.

Green Peafowl *Pavo muticus*. Vulnerable. Two, both from Sofia Zoo:

- 563 Ad male, died 13 April 1910. L 2,040, A 495, C –, R 46.4, T 155, D 103.
- 564 Ad female, died 12 December 1897.

GRUIDAE

Blue Crane *Anthropoides paradisea*. Vulnerable. One, from Sofia Zoo:

- 515 Unsexed, died 13 September 1900. L 1,320, A 518, C 545, R 72, T 222, D 82.

Red-crowned Crane *Grus japonensis*. Endangered. CITES I. One, from Sofia Zoo:
- 513 Ad male, died 18 October 1906. L 1,470, A 680, C 330, R 156, T 305, D 127.7.

RALLIDAE

Corncrake *Crex crex*. Vulnerable. Three:
- 208 Ad male, died in Sofia Zoo 16 August 1893.
- 209 Ad male, 18 May 1894, Çekmece (20 km W of Istanbul, Turkey), coll. A. Alleon. L 263, A 140, C 65, R 21.0, T 33.4, D 37.6.
- 210 Juv, Bulgaria.

OTIDIDAE

Great Bustard *Otis tarda*. Vulnerable. Five:
- 593 & 2497 Ad males, 10 January 1928, Euxinograd [near Varna, NE Bulgaria].
- 594 Ad male, 22 February 1940, Bozhurishte near Sofia (W Bulgaria). L –, A 632, C 265, R 42.5, T 163, D 77.
- 2496 Ad female, January 1890, Central Market of Sofia. L 915, A 513, C 280, R 38.7, T 123, D 57.5.
- 2498 Ad female, 20 January 1896, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon.

SCOLOPACIDAE

Slender-billed Curlew *Numenius tenuirostris*. Critically Endangered. CITES I. Six:
- 406 Ad female, 31 March 1914, Sofia (W Bulgaria).
- 407 Ad male, 24 March 1899, Mramor [near Sofia].
- 408 Ad female, December 1892, Istanbul (Turkey), coll. A. Alleon.
- 2772 Ad male, 28 March 1890, Kumanitsa near Sofia.
- 2773 Ad female, 11 September 1895, Makriköy (10 km WSW of C Istanbul, Turkey), coll. A. Alleon. L 445, A 267, C 112, R 91, T 69, D 36.7.
- 2774 Ad male, received on 26 March 1899 from somewhere in Bulgaria. L 455, A 263, C 117, R 75, T 64, D 36.5.

COLUMBIDAE

Luzon Bleeding-heart *Gallicolumba luzonica*. CITES I. Four, all from Sofia Zoo:
- 707 Ad male, died 30 October 1898. L 295, A 165, C 115, R 17.8, T 33.6, D 32.8.
- 708 Ad male, died 10 October 1899.
- 709 Ad female, died 5 February 1899. L 272, A 150, C 98, R 15.7, T 31.2, D 33.5.
- 710 Ad, no data.

Nicobar Pigeon *Caloenas nicobarica*. CITES I. Three, from Sofia Zoo:
- 773 Ad male, died 23 October 1911. L 345, A 290, C 115, R 23.8, T 45, D 34 (without claw).
- 774 Ad female, died 14 December 1898.
- 775 Juv male, died 23 September 1909. L 318, A 192, C 102, R 28.8, T 44, D 44.4.

Western Crowned Pigeon *Goura cristata*. Vulnerable. Two, both from Sofia Zoo:
- 736 Ad female, died 12 December 1898. L 770, A 345, C 265, R 37.0, T 92, D 68.
- 737 Ad female, died 26 September 1901. L 670, A 350, C 220, R 30.8, T 83, D 63.

CACATUIDAE

Palm Cockatoo *Probosciger aterrimus*. CITES I. One:
- 1785 Ad, ex Nehrkorn Mus. L 780, A 395, C 274, R 107.8, T 31, D 75.

Yellow-crested Cockatoo *Cacatua sulphurea*, ssp. *parvula*. Critically Endangered. One, from Sofia Zoo:
- 1843 Ad female [Timor], died 10 March 1895. Earlier Boev (1990) listed this specimen as *C. s. occidentalis*, but Timor Island is inhabited by *C. s. parvula* (del Hoyo *et al.* 1997). L 420, A 224, C 114, R 34.7, T 24, D 39.7.

Salmon-crested Cockatoo *Cacatua moluccensis*. Vulnerable. CITES I. One:
- 1847 Ad, no further data. L 660, A 355, C 196, R 50.2, T 32, D 68.4.

PSITTACIDAE

Swift Parrot *Lathamus discolor*. Endangered. One:
- 1893 Ad male. L 254, A 122, C 116, R 12.6, T 11.7, D 25.

Black-cheeked Lovebird *Agapornis nigrigenis*. Vulnerable. Three, all from Sofia Zoo:
- 1873 Ad male, died 12 July 1923. L 157, A 96, C 57, R 14.4, T 11, D 20.
- 1874 Ad male, died 30 June 1920.
- 1875 Subad female, died 1918. L 180, A 100, C 53, R 15.3, T 11.7, D 24.

Sangihe Hanging-parrot *Loriculus catamene*. Endangered. Two:
- 1852 Ad male, coll. Russ. L 130, A 81.2, C 40, R 10.4, T 9, D 12.6.
- 1853 Ad female, coll. Russ. L 141, A 83, C 44, R 9.4, T 11.4, D 17.6.

Lear's Macaw *Anodorhynchus leari*. Critically Endangered. CITES I. One:
- 1783 No data (old specimen). L 800, A 413, C 360, R 76.8, T 27, D 92.

Hyacinth Macaw *Anodorhynchus hyacinthinus*. Endangered. CITES I. One:
- 1784 Ad, bought from Hagenbeck in Hamburg by Sofia Zoo on 7 April 1937, died 30 January 1940. L 1080, A 332, C 600, R 88.8, T 45, D 105.

Golden-capped Conure *Aratinga auricapilla*. Vulnerable. Two:
- 1797 Ad male, died in Sofia Zoo on 31 August 1909. L 352, A 79, C 79, R 27.2, T 8, D 35.
- 1798 Ad male, no further data.

Red-spectacled Amazon *Amazona pretrei*. Vulnerable. One:
- 5166 Ad male, Tucuman (Argentina), coll. by Carlos Berg, received from Denison (London). L 310, A 201, C 111, R 24.9, T 23, D 40.

Yellow-shouldered Amazon *Amazona barbadensis*. Vulnerable. CITES I. One:
- 1824 Ad, no further data (old specimen). L 389, A 203, C 138, R 30.2, T 18, D 41.

White-headed Amazon *Amazona leucocephala*. CITES I. Three:

- 1826 *Amazona leucocephala caymanensis* Ad male. L 350, A 193, C 125, R 28.6, T 23, D 50.
- 1827 *Amazona leucocephala leucocephala* Ad female. L 351, A 189, C 126, R 25.5, T 18, D 46.
- 5181 *Amazona leucocephala caymanensis* Unsexed, obtained from Expo Plovdiv, 1981. L 324, A 192, C 119, R 22.8, T 18, D 48.

Yellow-crowned Amazon *Amazona oratrix*. Endangered. One:

- 1825 Ad [Mexico]. L 435, A 217, C 148, R 40.4, T 23, D 52.

Carolina Parakeet *Conuropsis carolinensis*. Extinct (Fuller 1988). One:

- 1799 Ad male, died in Sofia Zoo on 21 June 1901. L 377, A 194, C 166, R 24.5, T 16.5, D 34.

Kakapo *Strigops habroptilus*. Critically Endangered. CITES I. One:

- 1833 Ad [New Zealand], bought from E. Boubée Fils (Paris). L 640, A 268, C 255, R 33.9, T 41, D 60.

TROGONIDAE

Resplendent Quetzal *Pharomachrus mocinno*. CITES I. Two:

- 722 Ad male, 1903, Guatemala, don. M. de Voigts-Rhetz. L 1,053, A 200, C 850, R 17.2, T –, D 34.
- 723 Ad male. L 780, A 213, C 630, R 21.4, T 17.7, D 24.7.

FRINGILLIDAE

Red Siskin *Carduelis cucullata*. Endangered. CITES I. One:

- 1921 Venezuela, died 12 July 1910 in Sofia Zoo. L 108, A 58, C 36, R 8.9, T 11.9, D 9.0.

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Museums, books and costs: public service *vs* private enterprise

by Andrew S. Richford

Museums house a variety of resources important for the research and preparation of manuscripts and artwork for new book and journal publications. In particular, they have collections of printed library materials and specimen collections of birds. In this paper, I focus mainly on prepared skins as a reference material for authors and artists, since these are by far the most heavily used non-library resources, although the importance of collections of eggs, nests, skeletons and tissue samples can be considerable for certain projects.

Authors preparing new books refer to skins for information on species identification, to resolve taxonomic issues, and to obtain data to confirm the geographic distribution of species and subspecies. In some cases their studies may establish new syntheses, while in others it is only necessary to check previously published results or resolve ambiguities in the published literature. Artists may also collaborate in such research, but mainly refer to skins to prepare new illustrations, usually combining measurements and information on plumage and form with data collected from photographs and detailed personal observations of living birds, whether wild or captive.

The growth of interest in birds and birdwatching has provided new information on birds and their biology, distribution and identification, and has also generated a growing market for new books on these subjects—field guides, reference handbooks, and books on avian biology and ecology. A synergistic relationship between avian scientists working in laboratory and field, museum workers, and professional and amateur birdwatchers has brought our knowledge of birds, and the books published on them, to a level of excellence scarcely conceived half a century ago when the first volume of Witherby's *Handbook of British birds* was published.

Many quality publishers have played their part in these advances, through careful and conscientious production and publication of books to the highest standards of the day. Each new book seeks to include the latest research and information, so regular reference to museum specimens and libraries is a continuing need. For example, while many different illustrations of, say, gulls or warblers have been published over the years, each new generation of illustrators has been able to incorporate new information on the plumage details of newly recognised taxonomic groups or on the fine distinctions between the different age and sex classes. This all advances our knowledge of species limits and field identification.

There will never be an end either to research on birds or to the need for new and better illustrated books. Museums and their collections have a key role to play in these advances, through the provision of resource material. In return, the work of many authors and artists often helps curators to understand their collections better and sometimes even to revise and refine the organisation and cataloguing of the skins in their care.

The natural history specimens assembled in the world's museums represent a heritage asset of outstanding importance. In a perfect world, this material would be held as a free public resource, contributing to and benefitting from the work of scientists and dedicated amateurs, as well as providing an educational resource for the wider public. The material held in museum collections also has an international context. It has commonly been gathered and donated by generations of fieldworkers, of many nationalities, operating all over the world, often with the explicit requirement that this material is for the use and edification of the public. Many specimens have been donated by the great philanthropists of the past. These collections are precious, important and in many cases simply irreplaceable—a historic and living treasure trove. In past centuries the main purpose of natural history museums was to catalogue the world's species; now they are also used to describe evolutionary change and the patterns of biodiversity, and to inform our efforts at conservation in a changing world.

But a trend is appearing that threatens the traditional constructive synergies. Increasingly, the funding necessary to maintain and curate museum collections is in short supply. In the U.K. in particular, budgets are dwindling and museums are being forced by their managers to find funds on their own account. A 'user pays' philosophy is starting to spread, leading to such things as entrance charges to the public and 'bench fees' for any users of skin collections, including bird artists, who are considered to be likely to benefit commercially as a consequence. Currently this tendency appears to be rare in Europe and only in its infancy in the U.S.A.; artists may be charged for actual expenses incurred in sorting or posting specimens, but not for time spent working in the collections. In many museums in the U.K., however, artists are now routinely charged for merely referring to skins at the museum bench. Museum curators and managers seem generally unhappy with the need to make such charges, but are left with little option in the face of reduced funding and management pressure from above.

Publishers, meanwhile, are always squeezed on the one hand by costs and on the other by market price resistance. A lavishly illustrated field guide often costs less than one of a pair of training shoes, yet is certainly far more expensive to produce. Publishing is a low-margin business. The list price charged for a book must cover fees and royalties to authors and artists, direct costs of copy-editing, origination, printing and binding, booksellers' and agents' discounts, and the publisher's overheads of staffing, marketing, warehousing and distribution as well as returning a working profit. This is a huge claim on the price of an average field guide or reference handbook. Bird books also ofen have large numbers of colour illustrations and are relatively expensive to produce: printing costs are high, despite constant improvements in the industry, and artists must of course be paid a living wage to produce the copious original artwork that illustrates new and better books. Yet many high-quality bird books are still quite specialist in nature, and print runs are relatively modest when compared to high-street bestsellers. Hence the cost of producing them must somehow be borne by a modest customer base.

Extra costs always increase the price of books. When bench fees are charged, artists usually cannot afford to absorb them within their usual prices, and must pass the charge on to the publishers, who must in turn pass these costs on to readers through the book price. Hence the 'user pays' regime ultimately identifies the reader as the user. Perhaps this is as it should be in a capitalist society; but in my view the bench fee system engenders more evils than solutions. Although the fees that are charged are currently moderate, and seem to be charged only to artists, not to authors, they are a growing pressure on the costs of book preparation and hence book price. But being small, how much do they really address the financial difficulties of museums? How much of the charge is left after administration costs? It is easy to think that they are more to do with the philosophy of museum funding and access than the reality of solving the funding problem. But what if charging becomes more widespread, or charges increase so as to really generate worthwhile income, or authors are also charged for access to library and specimen resources? The impact on publishing and the price of books would be considerable. Books would really rise in price. Specialist books for smaller markets—arguably including some of the most valuable to the research community—would not be published at all if the price to be charged exceeds the publisher's expectation of what the market can realistically bear. Fewer, more expensive books will represent a loss to the scientific, museum and lay communities alike. Alternatively, artists and publishers will be forced to shun museums which make charges, to the detriment of the quality of the books they produce. Some of these things are already happening. Field guide prices in particular—books where the illustration costs are a major factor—are becoming really quite expensive and some U.K. publishers no longer use the Natural History Museum collections at Tring.

Ideology regarding the function of museums and the right of public access to their resources comes head to head with economic reality, and each will have their own attitude to the dilemma. I believe that museums should hold fast to the principle that they are the guardians of a common world heritage as well as the providers of the fruits of that heritage. Those who preside over the governance and funding of museums should understand that the provision of free access to their collections is a public and moral duty, that books produced with reference to museum collections add to the common good, and that such books feed back directly into the work of museum curators. By contrast, publishing runs to business rules and can only be expected to work in this way. Competition will manage the problem of sensible price maintainance if costs can be controlled. Publishers can help by continuing to do good business by providing good books. They can help museums justify free provision of resources by making fulsome acknowledgement of museum help, by showing museum logos on title pages, and by providing a generous allowance of complementary books for museum libraries. Museums would thereby gain kudos and standing by participating in publishing projects as partners in an educational and research activity—an extension of the service to the public which lies at the heart of their guiding philosophy.

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Some reflections on the use of skins in bird illustration

by Martin W. Woodcock

The last fifty years have seen a huge increase in the use made by bird illustrators of museum skin collections. This has been almost exclusively due to the proliferation of textbooks and field guides to the birds of many parts of the world, using ever more comprehensive illustration coverage. Illustrators are obliged to refer to study skins for species they have never seen in the wild, and for information on intraspecific plumage variation owing to racial differences, gender, age, moult and/or feather-wear factors.

It is important for the artist using museum material to be aware of the information he or she can actually glean from skins, for this avenue of research is by no means the only one available, and indeed has to be amplified by other techniques (although these are outside the scope of this paper).

Many large museum collections have a wide (if mostly not comprehensive) range of species preserved as study skins. In some cases there are numerous examples of each species, from which one may select birds of different ages and sexes, and those collected in different geographical locations, showing subspecific variation. The opportunity to lay out different examples of birds, side by side on the museum bench, is of enormous value. Much present bird illustration would have been virtually impossible in the absence of this ability. However advanced field techniques become—in the way of optical equipment, netting birds, electronic images and other means—and however detailed a study can be made of an individual bird in the field, only the museum collection can provide actual and close comparison between different age groups, subspecies and so on.

Critical examination of skins can be used for information on exact plumage colouration and markings (subject to drawbacks discussed below), on comparative sizes and shapes of bill and feet, precise measurements of some features, and general morphological aspects such as an idea (necessarily approximate owing to differing styles of preservation) of body size, wing and tail shape and length. In a good collection, this can be done to compare a series of skins both for subspecific differences and for changes due to ageing, moult or feather wear. These factors receive an increasing coverage in modern bird books but were, with a few important exceptions, hardly covered at all in books published up to around the middle of the twentieth century. It is worth noting that, with the advent of sophisticated optical equipment and advanced field techniques, data observable on wild birds can be confirmed on museum skins, and *vice versa*.

It will, of course, be clear to anyone contemplating referring to study skins in order to make representations of live birds, that in no way can the skin give a dependable idea of the appearance of a bird in life. This is particularly important to acknowledge in terms of the phenomenon known as 'jizz', that is, such aspects as stance, usual positions of wings and tail, bulk or slenderness, and so forth. However, there are many other problems which arise from using museum material of which the illustrator has to be aware. Most obviously, a skin cannot be pulled around in order, for instance, to stretch the wings out (in some museums this particular problem has been addressed by preparing a skin with one wing outstretched, but this has serious implications for storage). The ability or opportunity to handle freshly dead birds immediately shows the disadvantage of a cabinet skin in this respect.

To continue with comparisons with a freshly dead bird, the cabinet skin, in the process of being made up, inevitably loses some of the natural lay of the feathers, and this can present quite specific problems in trying to assess how complicated plumage patterns, such as those on nightjars, Caprimulgidae, and gamebirds, Galliformes, appear in life. Also, techniques of preparation vary, and in some cases, in order to achieve a neat skin, some feathering (such as on the sides of the body) can be concealed. Features which may be very apparent in life, especially in small birds, can easily be lost entirely or to an important degree. Furthermore, the dried and shrunken legs and feet on a skin give very little idea of these features in life. Where it occurs, bare skin colour around the eye may be a feature in the field, but mostly fades in the skin, and colours of bill, legs and feet usually undergo major post-mortem change. These colours, together with that of the iris, are sometimes recorded on the collector's label, but older skins usually lack this information, and the terms used to describe colours are evidently subjective, so that one may be left having to interpret such names as 'plum', 'amethyst' and 'lake-red' (see below re colour guides).

A more insidious problem derives from post-mortem changes in plumage colouration, which can result from various causes. Fading occurs over a period of time, and foxing, where green or olive hues tend to go brown or even reddish-brown, may be apparent when a skin is compared with fresh material. This subject was discussed by Wagstaffe & Williamson (1947) when they drew attention to noticeable disparities in colouration in a range of species—including Ringed Plover *Charadrius hiaticula*, Hooded Crow *Corvus* (*corone*) *cornix*, Song Thrush *Turdus philomelos* and Bullfinch *Pyrrhula pyrrhula*—depending on whether they were freshly dead or conserved as skins over long periods. In old skins of the Chough *Pyrrhocorax pyrrhocorax*, for instance, the purple in the body plumage intensifies substantially; illustrations made from such skins may be misleading as a result, and this obviously has a bearing on illustrations purporting to show subtle variation in plumages of similar taxa. Other factors affecting colouration include prolonged exposure of fresh skins to sunlight, and chemicals used in skin preparation. Mercuric chloride, for instance, stains white feathers black, a phenomenon I have noted around the feet of a sandgrouse specimen. The problem is compounded by the fact that even in closely related species fading, for instance of yellow, may occur in one species but not in the other.

This whole problem highlights the lack of a reliable and easy-to-use colour guide, with a consistent nomenclature, which would be immensely useful in making definitive descriptions of plumage and soft-part colours in trapped or freshly collected birds. Such guides as have been attempted, going back to John Gould in 1839, are unsatisfactory for various reasons. In Ridgway's (1912) *Color standards and color nomenclature*, for instance, over 1,000 colour terms are used, but unfortunately the swatches showing these colours have faded since publication, the degree of change differing even between different copies of the book. The Villalobos *Atlas* (1947) uses over 7,000 colour swatches (far too many for most people to discriminate between) but at the other extreme, the most recent work by Smithe (1975) shows only 86 colours, although the text is informative; Pickford (1970) urged use of the Munsell scheme, developed in 1905, which has as many as 1,450 divisions based on 'hue', 'value' and 'chroma'. It should not, however, be impossible to produce a highly serviceable guide nowadays, with the benefit of modern technology.

An absolutely integral item of information that goes (or should go) with every skin is, of course, the collector's label, identifying the species, sex, locality of collection and so forth. There are, however, various pitfalls in using the information on labels (outlined in Rasmussen & Prŷs-Jones 2003, this issue). Apart from the documentation of colours in life, mentioned above (but often hard to squeeze onto the standard museum label when the data are complex to any degree), the specimen may have been incorrectly sexed or even entirely misattributed to species, and there are many problems in interpreting the actual locality (which commonly bears on the discrimination of subspecific characters). There is also the challenge, particularly to any user unfamiliar with taxonomy, of outmoded nomenclature, which commonly survives on labels.

In ideal situations, authors and artists should work closely together to ensure accurate artwork. In my experience, this happens too infrequently, for various reasons. Some authors are uninterested in artwork, some feel unable criticise it, while others are impossibly critical. Some authors and experts, on the other hand, can come up with very helpful and informed criticism. In most cases, it is just too difficult to get people together at the museum bench to look through all the relevant skins against the illustrations. In comprehensive works, this would be an extremely time-consuming task, on top of the time already spent in preparing the text and plates. However, the high quality nowadays of colour photocopies means that illustrators can at least circulate copies of their work for checking and comments.

Apart from the specific issues of working with skins, there are some points worth noting in the wider context of bird illustrators and museum collections. In these days of extensively illustrated textbooks on birds from all parts of the world, those institutions with the most comprehensive collections are becoming more and more essential for illustrators, and the collections in them subject to ever more handling. There are, in fact, rather a small number of museums with really good worldwide collections, mostly in the eastern United States and north-west Europe, so that illustrators living outside these areas have problems of access; costs must be incurred either by them or by their publishers. Also to be considered is the fairly recent imposition of charges for artists working in some collections. This may be justifiable in the light of the work being done for commercial reasons rather than scientific research (although it is at least arguable that the creation of accurate images of species, whether commercial or not, is a form of science—after all, some species were described on the basis of their illustration—and is certainly a contribution to the ability of fieldworkers, often conducting scientific surveys, to report with confidence on their observations). However, these costs are passed on by publishers to the consumer in the final price of the book (see Richford 2003, this issue), and it is already evident that prices of some important reference works have drifted well beyond the reach of many would-be purchasers in poorer parts of the world. This circumstance reduces their contribution to the dissemination of ornithological knowledge.

The ever-increasing use of skin collections by researchers from all over the world, and the consequent frequent handling of skins, poses a curatorial conservation problem. Damage to skins includes broken or missing legs, and wings or heads falling off. Labels also become detached when tied loose or to a leg that falls off—and why are not workers handling valuable and indeed irreplaceable skins not required to wear surgical gloves (or at least required to wash their hands thoroughly before each session at a bench)? When illustrators in particular are concerned, it is possible that the imposition of charges and publishers' deadlines may lead to more hurried work, which also is not conducive to maintaining collections in the best condition.

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An inventory of major European bird collections

by C. S. Roselaar

Introduction

During a Round Table Discussion convened by Dr Walter Bock and Dr Henri Ouellet at the XXI International Ornithological Congress in Vienna, 20–25 August 1994, a number of staff members of European ornithological collections expressed the opinion that more cooperation among them was desirable. Many museums suffer from shrinking budgets, making improvement, maintenance, or even access to the collections difficult. Maintaining the world's biodiversity is of major concern among biologists at the moment, and although this concern is also acknowledged by various governments it has not resulted in any additional support for museum ornithology.

Bird collections form a rich source of biodiversity data. Taxonomic information in regional and global handbooks can only be extracted from museum collections. Morphometric data taken from skins of various populations are of importance for unravelling migration patterns for instance. Population studies profit from collections of specimens of known age and sex. Reference collections for identification and training will always be needed, both for laymen (e.g. rarity committees) and scientists (e.g. as help in enforcement of CITES and other national and international nature conservation legislation, for the statistics of bird/aircraft collisions, archaeology, and in ecological studies). Recently, bird skins or feathers have acquired additional relevance as a source of DNA for phylogenetic and population studies. Biochemical data have become a major source of phylogenetic information, from the level of populations up to the level of phyla, but can only be interpreted with reference to collections of entire organisms.

The main aims of this inventory are to facilitate the exchange of data among bird staff of European museums and to provide information to potential users of bird collections about the material available and their whereabouts. The information on which this inventory is based was obtained by sending questionnaires to those major European ornithological collections of which the addresses could be found. In all, 190 questionnaires were distributed, of which 160 were returned. For *c.*100 other collections presented here data derive from websites, country lists, various literature (e.g. Stresemann 1951, Gebhardt 1964–1974, Mearns & Mearns 1998), or from colleagues in nearby museums. The data given below are mostly the words of the various respondents, and therefore vary somewhat in thoroughness. Under the title References it is explained that the citations are, with some editing, as supplied by correspondents; however, it should also be noted that short references given in the texts, usually without titles of the papers, are again as given by correspondents.

Minor collections (fewer than *c.*4,000 study skins or fewer than 5,000 bird items) as well as collections for which only limited data were available (e.g. because the curators did not respond to the questionnnaire) are included in the 'B-list'. This list is likely to contain some more important collections, and a few major collections may have been overlooked entirely. Readers are kindly requested to send the author details of any collection they know of, or other data omitted from the main list (although, for reasons of space, no collections with fewer than *c.*100 well-labelled bird items will be included). These may then be included in a next version of this inventory (e.g. an updated electronic one). I offer my apologies for any omissions from my side. Note that this inventory was mainly based on the answers of the respondents and did not include literature research; when checking the literature references supplied by the various respondents, further details on the included collections and others are likely to be found.

Appendix 1 lists museums by country. Appendix 2 assigns major collectors to the museum to which their collections (largely) went. Appendix 3 tabulates the top 129 European museums in terms of size of collection, with equivalent non-European museums for comparison.

The 'A-list', based largely on the questionnaires received

The data presented for the 109 bird collections on the A-list follow the structure of the questionnaire. Entries are listed alphabetically by cities, with preferred acronym added (occasionally deviating from that proposed in Leviton *et al.* 1985). The first four paragraphs below the heading of each collection contain present-day addresses and details of the staff involved with birds. The date on which the questionnaire was received or updated is added: the details as shown were valid at least on that date. The next four paragraphs present some details on the history of the collection, including some of the more important contributors; in the list of important collections represented, those of staff members mentioned in the previous paragraph are not repeated. The last five paragraphs give some details on the present-day contents of the collection, including the number of skins represented and specialities.

The A-list includes data from collections which include *c.*4,000 or more bird skins for scientific study, or, for those which have less, have important numbers of skeletons, anatomical specimens or other bird items. Please note that the size of a collection (expressed in number of bird items available) is not the only value to judge its importance: the presence of type specimens, skins or mounts of rare or extinct birds, or of skins from areas not or poorly covered by other museums, may make small collections particularly noteworthy.

Note that the 'Tring collection' mentioned in much of the older literature refers to the private collection of Lord Rothschild, not to the present-day BMNH (now Natural History Museum) collection in Tring (which was in London up to 1972); Lord Rothschild's collection (the largest private collection ever gathered, with 280,000 skins) was sold to the American Museum of Natural History in New York in 1931.

Altenburg (MMA)

Info from: N. Höser, 25 Jul 1996

address Naturkundliches Museum Mauritianum, Postfach 1644, D-04590 Altenburg, Germany (visitors address: Parkstraße 1, D-04600 Altenburg)

telephone and fax #-49-3447-2589

staff responsible for bird coll. Dr Norbert Höser (head), Mike Jessat (coll. manager)

total staff of bird dept. 1 head, 1 coll. manager

brief history Founded in 1817 by the Naturforschende Gesellschaft des Osterlandes zu Altenburg; the coll. came to government of Thüringen in 1945.

references to history, collections, or types —

important past bird staff C. L. Brehm, Hugo Hildebrandt

important collections come from —

approx. nr. of bird skins 3,600 (1,300 species)

other bird items 100 skeletons, 200 birds in alcohol, 200 egg sets, 10,000 biometrical data of ringed birds

approx. recent annual increase in skins 40, from local skins, made by private taxidermist

bird skin collection specialised in Germany, East Africa, Australia

card or computer system present all skins on card, computer in preparation

Amsterdam (ZMA)

Info from: J. Wattel, 19 Sep 1994, updated by T. Prins, 10 Nov 2001

address Zoölogisch Museum, University of Amsterdam, Postbus 94766, NL-1090 GT Amsterdam, The Netherlands (visitors address: Mauritskade 61)

telephone #-31-20-525-5423/5422, **fax** #-31-20-525-7238, **e-mail** tprins@science.uva.nl, roselaar@science.uva.nl

staff responsible for bird coll. Tineke Prins, Drs Cees S. Roselaar

total staff of bird dept. 1 coll. manager, 1 information officer, 1 taxidermist

brief history Founded in 1838 by the Royal Zoological Society 'Natura Artis Magistra'; sold to the University of Amsterdam in the 1930s; the real increase in the coll. did not start until the arrival of the first curator of birds in 1945

references to history, collections, or types Roselaar (1990), Prins (1992), Roselaar & Prins (2000)

important past bird staff Max Weber, Max Fürbringer, L. F. de Beaufort, Karel H. Voous, Jan Wattel

important collections come from O. Bamberg, W. Barentsz Exped. (W. Bierman, H. van der Lee), L. P. le Cosquino de Bussy, G. B. Dinesen, R. von Dombrowski, A. Eriks (eggs), J. A. van Franeker, G. A. Frank, H. Grün, G. A. L. de Haan, A. F. C. A. van Heyst, D. S. Hoedt, C. G. B. ten Kate, V. A. Khakhlov, J. P. Kleiweg de Zwaan, J. de Korte, A. Kovacs, J. Laenen, H. Baron Loudon, J. G. van Marle, G. A. Mavromonstakis, S. C. J. W. van Musschenbroek, C. J. Neijssel (eggs), C. Ragioneri, E. Schmitz, J. A. Sillem, W. G. N. van der Sleen, R. C. E. G. J. Baron Snouckaert van Schauburg, R. Tancré, R. von Thanner, C. Waldeck, C. J. M. Wertheim

approx. nr. of bird skins 53,000 (c. 4,000 species)

other bird items 1,000 skeletons, 500 in alcohol, 5,000 egg sets, 8,000 spread wings, 6,000 microscopic feather preparations, 30,000 system cards with biometrics of birds received dead but not retained in coll.

approx. recent annual increase in skins 150, mainly local birds skinned by own taxidermist

bird skin collection specialised in Netherlands, Palearctic, Indonesia, Netherlands' Antilles; petrels, waders, skuas, pigeons, birds-of-prey, owls, passerines; c.150 types, c.20 extinct birds

card or computer system present 80% of skins on card, 50% on computer

Athens/Athinai (ZMUA)

Info from: A. Legakis, 07 Feb 1995

address Zoological Museum, Dept. of Biology, University of Athens, Panepistimioupolis (Kouponia), GR-15784, Athens-621, Greece

telephone #-30-1-7284609 or 7293993, **fax** #-30-1-7284604, **e-mail** alegakis@atlas.uoa.ariadne-t.gr

staff responsible for bird coll. Prof. Dr A. Legakis, G. Handrinos (volunteer associate)

total staff of bird dept. 0

brief history Founded 1835 by the Natural History Society of Athens; became part of the University of Athens in 1858

references to history, collections, or types Lindermayer (1840), Krüper (1862)

important past bird staff Th. Krüper, A. Kanellis

important collections come from L. & G. Schrader
approx. nr. of bird skins 2,500 (2,000 species)
other bird items a few skeletons, 500 eggs, 100 nests
approx. recent annual increase in skins 5, from donations
bird skin collection specialised in Greece, Balkans
card or computer system present none

Barcelona (MZBA)

Info from: E. Garcia, 25 Oct 1996
address Museu de Zoologia de Barcelona, Apt. 593, E-08080 Barcelona, Spain (visitors adress: Parc de la Ciutadella, Pg. Picasso s/n, E-08003 Barcelona)
telephone #-34-3-319-6912, or -501, **fax** #-34-3-310-4999
staff responsible for bird coll. Eulalia García Franquesa, Francesc Uribe
total staff of bird dept. 1 head, 1 coll. manager, 1 taxidermist
brief history Founded 1900; owned by the Council of Barcelona
references to history, collections, or types —
important past bird staff Ignaci de Segarra
important collections come from Aguilar-Amat, Domènech, De La Escalera, L. Gómez
approx. nr. of bird skins 7,000 incl. 1,000 mounts (400 species)
other bird items 1,332 skeletons, 10 in alcohol, 24 egg sets, 1,137 sound recordings
approx. recent annual increase in skins 30, from local birds skinned by own taxidemist
bird skin collection specialised in Spain (esp. Cataluña), Ecuador, Thailand, Equatorial Guinea
card or computer system present all skins on card, part on computer

Bardejov (SMB)

Info from: M. Hromada, 4 Feb 1999
address Sarisske Museum, Natural History Dept., Radnicé nàm. 13, 08501 Bardejov, Slovakia
telephone 00421-935-4722630 **fax** 00421-935-4724966 **e-mail** sarmuz@netlab.sk
staff responsible for bird coll. Tomás Jászay (chief Nat. Hist. Dept.)
total staff of bird dept. 1 head, 1 coll. manager, 2 others (for entire Nat. Hist. Dept.)
brief history Founded in 1956 by Tibor Weisz, government-owned
references to history, collections, or types none
important past bird staff Tibor Weisz, Martin Hromada
important collections come from none
approx. nr. of bird skins 6,000 (incl c.900 mounts)
other bird items 3,550 sterna, 800 egg sets, many bird parasites and pellets of owls, a few skeletons, birds in alcohol, and nests
approx. recent annual increase in skins 30
bird skin collection specialised in Carpathians, Baltic Sea, Black Sea, Cuba, Argentina
card or computer system present All birds on card (including data on measurements etc.), over 500 skins from former Czechoslovakia on computer

Basel (NMBA)

Info from: Raffael Winkler, 17 Jan 1995
address Naturhistorisches Museum, Postfach 1048, CH-4001 Basel, Switzerland (visitors address: Augustinergasse 2)
telephone #-41-61-266-5500, **fax** #-41-61-266-5546
staff responsible for bird coll. Dr Raffael Winkler (head)
total staff of bird dept. 1 head, 1 coll. manager, 0.5 taxidermist
brief history Founded 1830, when the even older private coll. of H. Bernoulli came to the government
references to history, collections, or types Sarasin (1939)
important past bird staff F. Sarasin, Ernst Sutter
important collections come from Th. Andersen, W. Markl, M. Markl, G. Orcès, P. Sarasin, G. Schneider
approx. nr. of bird skins 25,000 (3,500 species)
other bird items 1,800 skeletons, 3,300 skulls, many in alcohol
approx. recent annual increase in skins 150, from local birds skinned by own taxidermist
bird skin collection specialised in Europe
card or computer system present all skins on card, 10% on computer

Belgrade/Beograd (NHMBEO)

Info from: Milica Ivovic, 14 Jan 2000

address Natural History Museum, Njegoseva 51, P.O. Box 401, 11000 Beograd, Yugoslavia

telephone #-381-11-3442 147, **fax** #-381-11-3442 265, **e-mail** animig@net.yu

staff responsible for bird coll. Dr Milica Ivovic (curator of birds), Dr Vaslav Vasic (director, bird specialist)

total staff of bird dept. 1 head, 1 taxidermist

brief history Founded 1895, belongs to the government

references to history, collections, or types See J. Rasajski (1982) *Glasnik prir. Muz. Beogr. (Ser. B)* 37, 107-125 (egg catalogue)

important past bird staff S. D. Matvejev

important collections come from O. Reiser

approx. nr. of bird skins 5,000 (350 species)

other bird items 90 skeletons, 150 birds in spirits, many egg sets

approx. recent annual increase in skins 50, from expeditions, buyings, donations, local birds skinned by own taxidermist

bird skin collection specialised in Serbia, former Yugoslavia, Balkan area generally (the coll. formed the base for the monographs on Yugoslavian birds of Matvejev & Vasic)

card or computer system present partly on card

Bergen (ZMBN)

Info from: I. Byrkjedal, 19 Jan 1995, updated 19 Nov 1999

address Zoologisk Museum, Vertebrate Section, University of Bergen, Muséplass 3, N-5007 Bergen, Norway

telephone #-47-55-212902/ 05, **fax** #-47-55-321153, **e-mail** ingvar.byrkjedal@ zmb.uib.no, **web-site** http://www.zoo.uib.no/systematikk/samlinger/eng/birds

staff responsible for bird coll. Dr Ingvar Byrkjedal, Gunnar Langhelle

total staff of bird dept. 1 head, 1 taxidermist

brief history Founded 1825 as Bergens Museum (a general museum); the first vertebrate curator, S. Johnsen, was appointed 1913. The coll. came to the University of Bergen when the latter was founded in 1948

references to history, collections, or types —

important past bird staff S. Johnsen, J. F. Willgohs

important collections come from —

approx. nr. of bird skins 6,194 (688 species)

other bird items 144 in alcohol, 2,554 egg sets, 1,254 incomplete skeletons, 8,000 nest cards, 1 type specimen; also 3,400 recent complete skeletons, but in separate archaeological section with staff of 5

approx. recent annual increase in skins 200, from local birds skinned by own taxidermist

bird skin collection specialised in Western Norway, *Passer domesticus* (c.1,000), Tetraonidae, Falconiformes, etc.

card or computer system present all skins on card and on computer

Berlin (ZMB or ISZ)

Info from: B. Stephan, 26 Nov 1996; S. Frahnert, 13 Nov 1999

address Museum für Naturkunde, Zentralinstitut der Humboldt-Universität, Institut für Systematische Zoologie, Invalidenstrasse 43, D-10115 Berlin, Germany

telephone #-49-30-2093-8512, **fax** #-49-30-2093-8528, **e-mail** sylke.frahnert@rz.hu.berlin.de

staff responsible for bird coll. Dr Sylke Frahnert, Jürgen Fiebig, Frank Steinheimer

total staff of bird dept. 1 head, 1 taxidermist

brief history Founded 1810 together with the university. Part of the Humboldt-University

references to history, collections, or types Stresemann (1954), Mauersberger (1988), Neumann & Mauersberger (1990)

important past bird staff J. C. Graf von Hoffmansegg, J. C. W. Illiger, H. Lichtenstein, F. Deppe, J. L. Cabanis, A. Reichenow, H. Schalow, P. Matschie, E. Hartert, O. Neumann, H. Grote, G. Krause, R. Böhm, E. Hesse, W. K. H. Peters, E. Stresemann, G. Mauersberger, B. Stephan

important collections come from W. Beick, R. A. Berger, R. Böhm, Maison Bouvier, W. Bullock coll./Mus. Leverianum (see Wien/ Vienna), J. Bürgers, C. Baron von der Decken, F. Deppe, C. G. Ehrenberg, Emin Pascha, C. Euler, E. F. Eversmann, F. von Faber, O. Finsch, G. A. Fischer, G. W. Freireiß, F. Fülleborn, F. Grabowsky, R. Grauer, J. Gundlach, F. Heilfurth, G. Heinrich, O. Heinroth, W. Hemprich & C. G. Ehrenberg, J. M. Hildebrandt, C. Hilgert, Exp. J. Holderer, C. Hüesker, C. Hunstein, H. von Ihering (eggs), A. Kaiser, F. H. von Kittlitz, T. Kleinschmidt, A. C. & L. Koch, L. Krebs, J. S. Kubary, H. Kühn, G.

H. von Langsdorff, R. Mell, J. J. Menden, A. Nehrkorn (20,000 eggs), P. S. Pallas, W. Peters, C. C. Platen, V. von Plessen, F. W. Riggenbach, K. Roehl, E. Rüppell, E. Schäfer, R. Schomburgk, H. Schubotz, A. Schultze, F. Sellow, S. S. Sin, G. Stein, A. von Treskow (eggs), Voy. Gazelle, H. Weigold, E.Weiske, G. Zenker, R. Zimmermann

approx. nr. of bird skins 135,000 ('nearly all known species represented')

other bird items 7,000 mounts, 4,000 skeletons, 5,000 in alcohol, 55,000 eggs, 1,500 nests; 2,900 type specimens

approx. recent annual increase in skins 100–400, from local birds skinned by own taxidermist, birds obtained on expeditions, and donations

bird skin collection specialised in worldwide (but especially China, Mongolia, Korea, Burma, New Guinea, Afrotropics, Central & South America, Kerguelen, etc.); virtually all families represented

card or computer system present all skeletons and part of egg coll. on card, no skins; alcohol specimens on computer

Bern (NMBE)

Info from: M. Güntert, 25 Apr 1997, updated 18 Dec 1997

address Naturhistorisches Museum Bern, Bernastraße 15, CH-3005 Bern, Switzerland

telephone #-41-31-350-7222, **fax** #-41-31-350-7499, **e-mail** guentert@nmbe.unibe.ch

staff responsible for bird coll. Prof. Dr Marcel Güntert (director, also responsible for bird coll.)

total staff of bird dept. 1 head and some technicians and taxidermists (for the entire vertebrate coll.)

brief history Founded 1802 when the coll. of the Rev. Daniel Sprüngli was donated to the municipality after his death. Still owned by the municipality of the Burghers of Bern

references to history, collections, or types Meisner (1824), Güntert *et al.* (1993)

important past bird staff Friedrich Meisner, Theophil Studer, Emil August Goeldi

important collections come from E. A. Goeldi, J. Gould, J. & P. Henrici (eggs), T. J. Krüper, Gilbert Pochelon (eggs), W. Volz

approx. nr. of bird skins 13,200, incl. mounts

other bird items 1,200 skeletons & skulls, 100 in alcohol, 8,550 egg sets, 410 nests

approx. recent annual increase in skins ?

bird skin collection specialised in Switzerland, Brazil (Goeldi coll., 3,000 skins)

card or computer system present Skin coll. now being computerised, but not quite ready by late 2002. See http://www-nmbe.unibe.ch

Bologna (INFS)

Info from: N. Baccetti, 5 Apr 2000

address Museo dell'Istituto Nazionale per la Fauna Selvatica, Via Ca' Fornacetta 9, I-40064 Ozzano dell'Emilia (Bologna), Italia

telephone #-39-051-6512218, **fax** #-39-051-796628, **e-mail** infsmuse@iperbole.bologna.it

staff responsible for bird coll. Dr Nicola Baccetti (head), Dr Lorenzo Serra (researcher), Dr Marco Zenatello (coll. manager), Adriano De Faveri (taxidermist)

total staff of bird dept. 4 (see above)

brief history Founded 1933 as a branch of the Zoological Museum of the University of Bologna; separated from the latter 1970. Older colls. were recently obtained

references to history, collections, or types Toschi (1969), Spagnesi (1993)

important past bird staff A. Ghigi, A. Toschi

important collections come from T. Pierotti, G. Altobello, E. Garavini

approx. nr. of bird skins 8,700 (c.500 species), excluding c.1,000 mounts

other bird items 150 skulls, 150 egg sets, a large number of traditional traps and bird-catching devices

approx. recent annual increase in skins 300, from local birds skinned by own taxidermist and private professionals, buying of colls., and donations

bird skin collection specialised in Italy (7,000), Libya, Ethiopia, Somalia, East Africa, Guatemala; Falconiformes, Charadriiformes, Strigiformes, Ciconiiformes. Coll. includes skins of several rarities (e.g. 31 *Falco biarmicus feldeggii*, 6 *Numenius tenuirostris*)

card or computer system present W Palearctic species on card and computer, others largely unregistered

note The Museo di Zoologia of the Università di Bologna (MZUB) has a small bird coll. which includes the Zaffagnini coll. of Italian birds (dating around 1910) and a minor part of the Altobello coll.; for a partial catalogue, see Marini (1985). The Museo di Anatomia Comparata of the same university has 376 anatomical specimens and (partial) skeletons of 161 bird species (Minelli & Taranto 2001)

Bolton (BOLMG)

Info from: Kathryn Berry, 23 Nov 2001

address Bolton Museums, Art Gallery, and Aquarium, Le Mans Crescent, Bolton (Manchester) BL1 1SE, U.K.

telephone #-44-1204-332197, **fax** #-44-1204-332241, **e-mail** natural.history@bolton.gov.uk

staff responsible for bird coll. Ms Kathryn Berry (Keeper of Zoology)

total staff of bird dept. 1 (see above, for all zoology)

brief history Founded 1883, owned by local government

references to history, collections, or types -

important past bird staff E. Gorton, A. Hazelwood

important collections come from B. King, F. G. Lupton, A. L. W. Mayo, F. Nisbet, F. W. Peaples, J. Pennington Thomasson, L. A. Pownall, L. Price, J. Wallrow

approx. nr. of bird skins 5,000

other bird items 500 (partial) skeletons, 5,500 egg sets, 180 nests

approx. recent annual increase in skins below 100

bird skin collection specialised in British Isles; some India, Australia, etc.

card or computer system present all on card, in process of being computerised

Bonn (ZFMK)

Info from: R. Van den Elzen, 29 Dec 1994, updated G. Rheinwald, 21 Jan 2000

address Zoologisches Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany

telephone #-49-228-9122-230, **fax** #-49-228-216979, **e-mail** r.elzen.zfmk@uni-bonn.de, **website** http://www.uni-bonn.de/museumkoenig

staff responsible for bird coll. Dr Renate Van den Elzen, Dr Karl-L. Schuchmann

total staff of bird sect. 2 scientists, 1 coll. manager, 0.25 secretary, 0.25 librarian, up to 6 others (biol. candidates etc)

brief history Founded in 1875 as private coll. of Alexander Koenig (who had c.21,600 skins at his death); the coll. came to the German government in 1940

references to history, collections, or types Rheinwald & Van den Elzen (1984), Van den Elzen (1986), Schifter & Van den Elzen (1986)

important past bird staff A. Koenig, O. le Roi, A. von Jordans, Fr. Neubaur, J. Steinbacher, G. Niethammer, H. E. Wolters, G. Rheinwald

important collections come from Th. Andersen (see Britton 1978, 1981), O. Bamberg, M. O. E. Baddeley, H. Bregulla, C. L. & A. E. Brehm (3,000 skins, stored separately; remainder of Brehm coll. in New York), P. A. Clancey, K. Dernedde, M. Eisentraut, Ms M. E. Ferreira, A. Fischer, C. Floericke, E. Flükiger, C. Fritsche, H. Geyr von Schweppenburg, H. Grün, J. Haffer, M. Härms, W. Hartwig, F. Haverschmidt, G. Heinrich, C. Hilgert, W. Hoesch, D. von Holst, G. Hoy, L. von Huyn, A. Kaiser, H. Kelm, O. Kleinschmidt coll. (over 10,000 skins, stored separately), Th. Kleinschmidt, Maria Koepcke, J. Klapperich, H. Kumerloeve, P. Kunkel, Künzel, J. Laenen, R. Lossin, W. Makatsch, J. Martens, J. von Müller, A. von Nagy, O. Natorp, R. de Naurois, G. Nikolaus, V. von Plessen, W. F. H. Rosenberg, E. Schäfer, G. Schiebel, W. Schlüter, G. Schrader, H. Sick, P. Spatz, R. Tancré, R. von Thannner, J. Unger, R. Vierthaler

approx. nr. of bird skins 76,000 incl. 3,500 mounts (5,000 species)

other bird items 2,000 skeletons (800 species), 500 in alcohol, 54–60,000 sets of eggs

approx. recent annual increase in skins 100 skins and 100 skeletons and birds in alcohol; obtained by own taxidermy and by buying of colls.

bird skin collection specialised in Afrotropics, North Africa, Germany, South America, Spain, Spitsbergen, Bulgaria, Turkey, Iran, Afghanistan; Trochilidae, Estrildidae, Fringillidae, passerines

card or computer system present eggs, skeletons, and spirit specimens all on computer, 30% of skins on card, another 30% on computer

Braunschweig (SNMBG)

Info from: G. Boenigk, 21 Oct 1996

address Staatliches Naturhistorisches Museum, Pöckelstraße 10, D-38106 Braunschweig, Germany

telephone #-49-531-3914351, **fax** #-49-531-3914370, **e-mail** Michaela.Forthuber@snhm.Niedersachsen.de

staff responsible for bird coll. Michaela Forthuber (taxidermist)

total staff of bird dept. 1 head (vacant), 2 taxidermists

brief history Founded in 1754 as private coll. of Herzog Carl I von Braunschweig und Lüneburg; now owned by the government of Niedersachsen

references to history, collections, or types Hajmassy (1983), Hinkelmann & Heinze (1990), Frisch *et al.* (1994)

important past bird staff J. H. Blasius, W. Blasius, E. F. von Homeyer, Adolf Kleinschmidt, G. Boenigk

important collections come from M. Bartels, A. E. Brehm, C. L. Brehm, F. Dörries, O. Finsch, F. Grabowsky, E. Hartert, E. F. von Homeyer (8,000 skins), A. Keyserling, H. Möschler, A. Nehrkorn (5,000 skins), C. C. Platen, H. Raap, J. Riedel, H. von Rosenberg, G. Schneider, R. Tancré

approx. nr. of bird skins 27,000 (3,700 species)

other bird items 2,800 skeletons, 400 egg sets, 700 nests

approx. recent annual increase in skins 30, from local birds skinned by own taxidermist and donations

bird skin collection specialised in Palearctic, Borneo, Sulawesi, etc.; 77 types

card or computer system present all skins on card, none on computer; eggs catalogued (see Hajmassy 1983)

Bremen (UMB)

Info from: H. Hohmann, 19 Aug 1997

address Überseemuseum, Bahnhofplatz 13, D-28195 Bremen, Germany

telephone #-49-421-171347/420438, **e-mail** uem7@uni-bremen.de

staff responsible for bird coll. Dr Herbert Hohmann (head of Natural History Dept.), Dr Horst Braun (bird dept.), Klaus Wechsler (taxidermist)

total staff of bird dept. 2

brief history Founded by the Bremen Natural History Society, but no proper bird coll. before the arrival of G. Hartlaub in 1840s

references to history, collections, or types Duncker (1953)

important past bird staff Gustav Hartlaub, Otto Finsch, G. A. Weber, Eberhard Focke, P. Becker

important collections come from Abel, Anchieta, Andersen, Andersson, T. Ayres, Balfour, A. E. Brehm, Bryant, Capt. Bulger, F. M. Chapman, Du Chaillu, Capt. Conrad, A. Dietrich, H. Dohrn, Emin Pascha (= Emin Bey, E. Schnitzer, A. Schnitzler), Fitzgerald, A. Garrettt, Mus. J. C. Godeffroy (duplicates only; see Hamburg), Gräffe, Grayson, J. Gundlach, J. von Haast, Capt. Heinsohn, Heuglin, Hoesch, Kirk, Knipper, A. Krause, J. Kubary, Lahusen, Meller, Monteiro, Joh. Natterer, Newton, H. S. Pel, Capt. Peters, Pollen, E. Riebeck, Rosenberg, O. Salvin, H. Schauinsland, B. Schmacker, G. P. Schmacker, Schultze, Speke, F. Stoliczka, H. T. Ussher, Verreaux, Vierthaler, H. O. Wagner, Wahlberg, K. Weiß, Maximilian Prinz zu Wied-Neuwied, Paul Herzog von Württemberg (c.9,000 skins), J. Xantus, Zimmermann

approx. nr. of bird skins over 20,000 of which c.25% mounted

other bird items ?

approx. recent annual increase in skins very few

bird skin collection specialised in Afrotropics (incl. São Tomé, Príncipe, Socotra, Madagascar, Mauritius), Central and South America, and from many Pacific islands (from Hawaii to Pelew and Lord Howe); c.200 type specimens; 3,313 specimens lost during World War II, including some types

card or computer system present ?

Brighton (BMB)

Info from: Jeremy M. Adams, 23 Nov 2001

address Booth Museum of Natural History (Brighton and Hove Council Museums), 194 Dyke Road, Brighton BN1 5AA, E Sussex, U.K.

telephone #-44-1273-292782, **fax** #-44-1237–292778, **e-mail** boothmus@ pavilion.co.uk

staff responsible for bird coll. Dr Gerald Legg (curator of zoology), Jeremy M. Adams (ass. curator natural sciences)

total staff of bird dept. 1

brief history Founded Brighton and Hove Council

references to history, collections, or types Griffith (undated), Knox (1998)

important past bird staff E. T. Booth, A. F. Griffith, J. G. Dalgliesh, H. Langston
important collections come from Major Bingham Crabbe, L. A. Curtis-Edwards, W. Borrer, P. Godman, G. M. Henry, A. W. Johnson, F. W. Lucas, Lt Col. B. F. Lynn Allen, T. J. Monk, J. B. Nichols, M. J. Nicoll, J. P. Nunn, T. Parkin, Capt. F. H. Scovil, E. C. Stuart Baker, G. Vick
approx. nr. of bird skins 10,000 (incl. 5,000 mounts)
other bird items 3,300 (partial) skeletons, 12 birds in spirits, c.60,000 eggs (33,334 catalogued), 262 nests
approx. recent annual increase in skins 40–120
bird skin collection specialised in worldwide, but mainly British
card or computer system present yes, but for only half of the eggs

Bristol (BCMAG)

Info from: Tessa Ivison, 6 Dec 2001
address Bristol Museums and Art Gallery Service, Queen's Road, Bristol BS8 1RL, U.K.
telephone #-44-117-9223598, **fax** #-44-117-9222047, **e-mail** tessa-ivison@bristol-city.gov.uk, ray-barnett@bristol-city.gov.uk
staff responsible for bird coll. Tessa Ivison (curator), Ray Barnett (coll. manager)
total staff of bird dept. 2 for all zoology (see above)
brief history Founded in 1820s; owned by Bristol City Council
references to history, collections, or types -
important past bird staff -
important collections come from Greville Smyth, Stanley Lewis
approx. nr. of bird skins 7,500 (incl. 2,500 mounts)
other bird items 600 (partial) skeletons, 2,400 egg sets (6,500 eggs), 300 nests
approx. recent annual increase in skins a few
bird skin collection specialised in SW England
card or computer system present most skins on card, computerisation in progress

Brno (LMB)

Info from: Helena Sutorova, 6 Jan 2000
address Moravské Zemské Muzeum, Zoologicesce Oddolení, Zelny trh. 6, CZ-659 37 Brno, Czech Rep.
telephone #-420-(0)5-42321205, **fax** #-420-(0)5-42212792, **e-mail** hsutorova@mzm.cz, **website** http://www.mzm.cz/
staff responsible for bird coll. Dr Miroslav Sebela (head), Dr Helena Sutorova, Ing Vaclav Prasek (curators)
total staff of bird dept. 1 head, 2 curators (see above), 2 taxidermists, 1 librarian-secretary (all for entire zool. dept.)
brief history Founded approx. 1816 as Franzens-Museum, but includes some older specimens from earlier colls.; government–owned
references to history, collections, or types Schramm (1886), Varga (1973), Kux (1977)
important past bird staff K. Absolon, E. Hachler, J. Hala, V. Capek, F. Chorinsky, F. Hejl, J. Karasek, Z. Kux, J. Mrazek, K. Plachetka, K. Hudec, F. Balat, J. Talsky, J. Tesar, E.S. Vraz, F. Zdobnitzky
important collections come from A. Schwab, J. Seilern, A. Koch
approx. nr. of bird skins 8,000
other bird items ?
approx. recent annual increase in skins 50–60, from own collecting expeditions, gifts, and buying of colls.
bird skin collection specialised in Moravia, former Czechoslovakia, Venezuela (see *Bull. Brit. Orn. Cl.* 115: 191-192).
card or computer system present ?
note also existing are the Zoologicke Depozitár of Budisov & Trebic (nearby Brno).

Brussels/Bruxelles (IRSNB/KBIN)

Info from: G. Lenglet, 06 Jan 1997
address Institut Royal des Sciences Naturelles de Belgique/ Koninklijk Belgisch Instituut voor Natuurwetenschappen, 29 Rue Vautier/ Vautierstraat, B-1000 Bruxelles/Brussel, Belgium
telephone #-32-2-6274349, **fax** #-32-2-6464433
staff responsible for bird coll. Dr Georges Lenglet (head of vertebrate dept; there is no separate bird dept), Walter Roggeman
total staff of bird dept. for entire vertebr. dept: 1 head, 1 taxonomist, 4 technicians
brief history Founded 1846; owned by the Belgian government
references to history, collections, or types —
important past bird staff B. Du Bus de Gisignies, Baron de Selys-Longchamps, René & Rudolf Verheyen, A. Prigogine, P. Devillers

important collections come from C. Dupond, J. Laenen, and many others
approx. nr. of bird skins 71,295 (3,000 species)
other bird items many skeletons, many egg sets, a few in alcohol, a few nests
approx. recent annual increase in skins 100, from local birds skinned by own taxidermist and donations
bird skin collection specialised in Belgium, Germany, west Mediterranean countries, North Africa, Iran, Himalaya, Central Africa
card or computer system present all skins on card, none yet on computer

Bucharest/Bucuresti (GAMNH / MGAB)

Info from: A. Petrescu, 24 Apr 1996
address Muzeul de Istorie Naturala / Museum of Natural History 'Grigore Antipa', Soseaua Kisseleff 1, 79744 Bucuresti, Romania
telephone ?, **e-mail** grantipa@pcnet.ro
staff responsible for bird coll. Dr Angela Petrescu
total staff of bird dept. 1 head
brief history Founded 1848 by Carol Wallenstein; now part of the Academy of Sciences of Romania
references to history, collections, or types Marinescu *et al.* (1972, 1985), Papadopol & Talpeanu (1986–1987)
important past bird staff R. von Dombrowski, A. Papadopol, M. Talpeanu
important collections come from E. Holub, P. J. Licherdopol, H. Mitrea
approx. nr. of bird skins 6,000 (2,000 species)
other bird items 1,000 skeletons, 100 in alcohol, 1,200 egg sets, 250 nests, 11,600 food samples
approx. recent annual increase in skins 50, from local birds skinned by own taxidermist, expeditions, and exchanges
bird skin collection specialised in 'many bird families'
card or computer system present all skins on card, none on computer

Budapest (HNHM)

Info from: A. Bankovics, 18 Jan 2000
address Magyar Nemzeti Muzeum/ Hungarian Natural History Museum, Dept. of Zoology, Baross utca 13, H-1088 Budapest, Hungary
telephone #-36-1- 2101075/ 2105044 **fax** #-36-1-1171669 **e-mail** bankovic@zoo.nhmus.hu
staff responsible for bird coll. Dr Attila Bankovics
total staff of bird dept. 1 head, 1 taxidermist (partly retired)
brief history Founded in the early 1800s, and the bird coll. was one of the largest in Europe in the early 1950s; however, it was destroyed in 1956, though now gradually rebuilding. A governmental museum
references to history, collections, or types A catalogue in preparation
important past bird staff J. Frivaldszki, S. J. Petènyi, G. Madarász, N. Vasvári, K. Warga, J. Gerschik, L. Horvath
important collections come from G. Almásy, A. Baldi, P. Beretzk, G. Csorba, C. Floericke, E. Frivaldszky, A. Keve (= E. Kleiner), L. Kovats, J. Xántus, etc, but colls. of many of these destroyed in 1956
approx. nr. of bird skins 70,000 by 1956, when destroyed; now 12,500 (1,200 species)
other bird items approx. 1,700 skeletons (200 species), 1,400 egg sets (250 species), 120 nests
recent annual increase in skin coll. 50, from own expeditions, donations, local birds skinnned by own taxidermist, etc.
bird skin collection specialised in now mainly Hungary, Brazil, Tanzania, Argentina, Australia, Vietnam, Korea, Mongolia; before 1956, many from Sudan, C & S America, C Asia, New Guinea, etc.
card or computer system present Partly on card; available on computer by 2001

Cambridge (CUMZ)

Info from: A. E. Friday, July 1996; update 19 Nov 1999 by M. Brooke
address University Museum of Zoology, Downing Street, Cambridge CB2 3EJ, U.K.
telephone #-44-1223-336659, **fax** #-44-1223-336676, **e-mail** mb10005@cus.cam.ac.uk
staff responsible for bird coll. Michael de L. Brooke, Ray Symonds
total staff of bird dept. 1 head, 1 coll. manager
brief history Founded 1815 as part of Cambridge University
references to history, collections, or types Salvin (1882), Gadow (1910), Benson (1970–1971, 1972, 1999)

important past bird staff H. E. Strickland, H. Gadow, Alfred Newton, O. Salvin, C. W. Benson, W. H. Thorpe
important collections come from Capt. Askew, E. Blyth, T. E. Buckley, Cambridge Philosophical Society, J. S. Constancia, F. Day, W. B. Farr, H. W. Feilden, P. H. Gosse, J. Gould, F. H. H. Guillemard, J. H. Gurney, G. D. Haviland, J. E. Hepburn, B. H. Hodgson, T. Horsfield, C. Hose, A. von Hügel, W. Jardine, T. C. Jerdon, J. J. Lister, Edw. Newton, J. Richardson, P. J. Selby, A. Smith, S. Stevens, H. E., A., & N. C. Strickland coll. (c.6,000 skins), W. Swainson, L. W. Wiglesworth, S. B. Wilson, J. Wolley egg coll. (see book *Ootheca Wolleyana*)
approx. nr. of bird skins 40,000 ('most species represented')
other bird items 2,200 skeletons, some in alcohol, c.8,000 egg sets
approx. recent annual increase in skins 20, from donations
bird skin collection specialised in Western Palearctic, South Africa, Madagascar, Mauritius, Seychelles, India, Borneo, Sulawesi, New Zealand, Fiji, Hawaii, California, eastern North America, Jamaica, Barbados, Central America; includes 104 skins of extinct and endangered birds (31 Hawaii, 19 Malagasy region, 16 New Zealand area, 13 West Indies), c.620 types
card or computer system present all skeletons on computer and website (zoo.cam.ac.uk); all skins on card, most on computer (for internal use only)

Cardiff (NMWC)

Info from: P. Howlett, 1996
address National Museum & Galeries of Wales, Dept of BioSyB, Cathays Park, Cardiff CF10 3NP, Wales, U.K.
telephone #-44-1222-397951, **fax** #-44-1222-239009
staff responsible for bird coll. Peter Howlett (curator of vertebrates)
total staff of bird dept. 1 head, 1 coll. manager
brief history Founded in the 1880s by the Trustees of the Cardiff Museum; now belongs to the government
references to history, collections, or types none
important past bird staff P. J. Morgan
important collections come from Hewitt, McCouch
approx. nr. of bird skins 20,000 (2,000 species)
other bird items 500 skeletons, 8,000 egg sets, 200 nest, 40,000 biometrical data of ringed birds
approx. recent annual increase in skins 150, from local casualties
bird skin collection specialised in Wales, Britain, Asia, Australasia
card or computer system present less than 50% of skins on card, none on computer

Coburg (NMC)

Info from: Dr Werner Korn, 28 Nov 2001
address Naturkunde-Museum Coburg, Park 6, D-96450 Coburg, Germany
tel #-49-9561-808111, **fax** #-49-9561-808140, **e-mail** info@naturkunde-museum-coburg.de
staff responsible for bird coll. Dr Werner Korn (head), Ulrike Neumann (taxidermist) (both for all zoology)
total staff of bird dept. 2 (see above)
brief history Founded as private coll. in about 1830 by the later Duke Ernst II von Sachsen-Coburg und Gotha and his brother Prince Albert, openend to the public in 1844; now belongs to the Landesstiftung Coburg (Stiftung des Öffentlichen Rechts).
references to history, collections, or types Korn *et al.* (1993)
important past bird staff H. von Boetticher
important collections come from C. L. Brehm, Th. von Heuglin, W. Baldamus, Ferdinand I of Sachsen Coburg-Gotha (King of Bulgaria)
approx. nr. of bird skins 14,500 (of which 14,000 mounted)
other bird items 15 skeletons, 3,000 egg sets
approx. recent annual increase in skins highly variable
bird skin collection specialised in worldwide, but largely historical; many Trochilidae
card or computer system present most on card, now revised and completed

Coimbra (MZCoimbra)

Info from: I. Carreira, 12 May 1997
address Museu de História Natural–Museu Zoológico, Faculdade de Ciências e Tecnologia da Universidade de Coimbra, Largo Marquês de Pombal, 3000 Coimbra, Portugal

telephone #-351-39-34729, **fax** #-351-39-26798
staff responsible for bird coll. Dra Isabel Machado Carreira
total staff of bird dept. 1 head
brief history Founded 1775 by Domingos Vandelli; now part of Coimbra University
references to history, collections, or types Themido (1933), Carreira (1984–1986, 1990)
important past bird staff Albino Giriddes, Paulino de Oliveira, A. A. Themido
important collections come from Nelo Beeyner, Luis de Carvalho, Teodoro J. Cruz, King Pedro V, Lopez Vieire
approx. nr. of bird skins 3,104 (1,092 species)
other bird items 44 skeletons, 1,129 egg sets, 238 nests
approx. recent annual increase in skins a few, mainly donations
bird skin collection specialised in Portugal, Brazil, Angola, Mozambique, São Tomé, Australia
card or computer system present all skins on card, part on computer

Copenhagen (ZMUC)

Info from: J. Fjeldså, 11 Jul 1996, and J. Fjeldså & C. Rahbek, 14 Nov 2001
address Zoologisk Museum, Københavns Universitet, Universitetsparken 15, DK-2100 København-Ø, Denmark
telephone #-45-3532-1023/ 1000, **fax** #-45-3532-1010, **e-mail** jfjeldsaa@zmuc.ku.dk
staff responsible for bird coll. Prof. Dr Jon Fjeldså (curator-in-charge), Prof. Dr Carsten Rahbek (curator), Jan Bolding Kristensen (coll. manager)
total staff of bird dept. 2 scientists, 1 coll. manager/taxidermist, 3 others (at staff of ringing centre)
brief history Founded 1805 by J. Reinhardt; now part of Copenhagen University/
references to history, collections, or types Preuss & Aaris-Sørensen (1981)
important past bird staff J. Reinhardt, Herluf Winge, P. Hald-Mortensen, F. Salomonsen
important collections come from T. Andersen, W. Beick, J. Fjeldså, Galathea Exp., K. & S. Harold Olsen, A. M. Hemmingsen, Hans Johansen, Hermann Johansen, N. Krabbe, P. W. Lund & J. Reinhardt, H. Möschler, Noona Dan Exp., A. M. Ollala, K. Paludan, E. L. Schiøler, J. Waterstradt
approx. nr. of bird skins 97,000, incl. 5,000 mounts (5,500 species)
other bird items 14,000 skeletons (1,100 species), 10,000 in alcohol (800 species), over 20,000 buffered tissue samples (over 2,000 species), 17,000 egg sets
approx. recent annual increase in skins 200–300 (sometimes much more), from local birds skinned by own taxidermist and own expeditions
bird skin collection specialised in Denmark, Greenland, Iceland, Fenno-Scandia, Brazil, Ecuador, Beidaihe (China), West Siberia, Iran, Afghanistan, Andes, south-west Pacific, Liberia, Tanzania, and many more
card or computer system present 90% of skins on card; tissue coll. on computer; South American and Afrotropical coll. on computer (incl. also many non-skin records)

Dresden (SMTD)

Info from: S. Eck, 18 Mar 1997
address Staatliches Museum für Tierkunde, Königsbrücker Landstrasse 159, D-01109 Dresden, Germany
telephone #-49-351-8926-344
staff responsible for bird coll. Siegfried Eck
total staff of bird dept. 1 head
brief history Founded 1728, but the oldest bird is now from 1810; part of the coll. was destroyed in 1940–1945. Owned by the government of Sachsen
references to history, collections, or types Meise (1929), Eck (1970, 1982–1985)
important past bird staff H. G. L. Reichenbach, A. B. Meyer, L. Wiglesworth, A. Jacobi, W. Meise, R. Reichert
important collections come from U. Bährmann (7,180 birds and many partial skeletons), F. Brüggemann, B. Berg, O. Burger, C. W. Cursham, F. von Faber, A. P. Farafontov, G. A. Frank, B. Geisler, H. Grün, H. Gude, W. Gueinzius, J. W. B. Gunning, B. Hantzsch, F. P. Heilfurth, H. W. Henshaw, M. Hinsche, C. Hunstein, V. A. Khakhlov, J. Klapperich, O. Kleinschmidt (coll. # 2; 1st in Bonn), Th. Krüper, J. Kubary, Kuschel (eggs), L. Laglaize, W. Makatsch (eggs), McGregor, J. J. Menden, H. Möschler, S. C. J. W. van Musschenbroek, H. Palmer, C. & R. Ragioneri, C. Ribbe, J. Riedel, C. Rolle, H. von Rosenberg, F. & P. Sarasin, Schierbrandt, R. Schlegel, C.

Schneider, C. Wahnes, H. Weigold (Stötzner Exp.), E. Weiske

approx. nr. of bird skins 70,000

other bird items many skeletons, a few in alcohol, 60,000 eggs, many nests

approx. recent annual increase in skins 150, from local birds skinned by own taxidermist and by buying of colls.

bird skin collection specialised in Germany (esp. east), Sweden, Iceland, Spain, Italy; Indonesia (esp. Wallacea & New Guinea), Philippines, China (Sichuan, Manchuria), Hawaii, E & S Africa, West Siberia, etc. Includes 31 skins and mounts and 19 eggs of extinct birds (24 species)

card or computer system present part of skins on card system (including birds destroyed during the war)

Edinburgh (RSM/ NMSE)

Info from: R. McGowan 06 Feb 1995 & 16 Nov 2001, A. Kitchener 13 Nov 1999

address National Museums of Scotland, Royal Museum of Scotland, Dept. Geology & Zoology, Chambers Street, Edinburgh EH1 1JF, Scotland, U.K.

telephone (DDI) #-44-131-247-4240, **fax** #-44-131-220-4819, **e-mail** a.kitchener@nms.ac.uk, b.mcgowan@nms.ac.uk, rym@nms.ac.uk

staff responsible for bird coll. Dr Andrew C. Kitchener (head of birds and mammal dept, mostly working on mammals), Robert (Bob) McGowan (curator of birds)

total staff of bird dept. 0.3 head, 1 curator, 0.3 taxidermist

brief history Founded c.1815 by Edinburgh University; both government-owned from c.1854

references to history, collections, or types Stenhouse (1924–1930), McGowan (1988), Herman *et al.* (1990)

important past bird staff A. S. Clark, W. Eagle Clark, J. H. Stenhouse, I. H. J. Lyster

important collections come from L. Adams, E. Baxter, W. Bullock coll./Mus. Leverianum (see Wien/Vienna), P. A. Clancey, L. Dufresne, T. P. Dutton (eggs), Edinburg Univ. Museum, J. A. Harvie-Brown, Annie C. Jackson, W. Jardine, P. P. King, Parry, J. Richardson, L. Rintoul, J. C. Ross, Scot. natl. Antarctic Exp., H. Seebohm, W. Serle, A. Smith, R. A. L. & V. G. L. Van Someren, C. Sturt, R. G. Wardlaw-Ramsay, H. Whistler, J. I. S. Whitaker

approx. nr. of bird skins 63,000 (6,000 species)

other bird items 4,000 skeletons, 33,000 egg sets, a few in alcohol

approx. recent annual increase in skins 200, from local birds skinned by own taxidermist and donations

bird skin collection specialised in 'worldwide (*c.*50% Palearctic), all families'. E.g. South Africa, Tristan da Cunha, Australia, Arctic regions

card or computer system present Only part of egg coll. on computer

Exeter (EXEMS or RAMM)

Info from: David Bolton, 4 Dec 2001

address Royal Albert Memorial Museum and Art Gallery, Queen Street, Exeter, U.K.

telephone #-44-1392-665358, **fax** #-44-1392-665858, **e-mail** david.bolton@exeter.gov.uk.

staff responsible for bird coll. Dr David Bolton (Curator of Natural History

total staff of bird dept. 1 (for all natural sciences)

brief history Founded 1865 by Sir Stafford Northcote as a memorial to Prince Albert, opened 1868; now owned by local governement (Exeter City Council)

references to history, collections, or types Lowe (1939), Howes (1969)

important past bird staff W. S. M. D'Urban, F. W. L. Ross, R. P. Nicholls, C. Blackie, A. B. Gay, W. P. Lowe

important collections come from R. H. Buller, W. T. H. Chambers, Cumming, Major-General Elliot, J. Gilbert, J. Gould, Hollis, Maxwell, Sir Wilfred Peek, Pershouse, Rolle, Mrs H. N. Rowan, General W. N. T. Smee, Sir John Walrond

approx. nr. of bird skins 8,500 (mainly mounted)

other bird items 200 (partial) skeletons, 50 in liquid, 1,000 egg sets, 100 nests, 100s of wings, heads, etc.

approx. recent annual increase in skins below 10

bird skin collection specialised in England (esp Devon) and USA, but in general worldwide; includes various types and an impressive number of extinct species (e.g. 9 each of *Ectopistes migratorius* and *Conuropsis carolinensis*)

card or computer system present Part on card, computerised database in progress

Florence/Firenze(MZUF)

Info from: A. Nistri, 26 Jul 1996

address Museo Zoologico de 'La Specola', Sezione del Museo di Storia Naturale , Università degli Studi di Firenze, Via Romana 17, I-50125 Firenze, Italia

telephone #-39-055-2288261, **fax** #-39-055-225325, **e-mail** specola@specola.unifi.it

staff responsible for bird coll. Dr Marta Poggesi (coordinator of vertebrate section), Dr Annamaria Nistri (coll. manager), Dr Anna Altobelli, Fausto Barbagli, Dr Silke Jantra (volunteer associates)

total staff of bird dept. 1 head, 1 coll. manager

brief history Founded 1775 as private coll. of Grand Duke Peter Leopold of Lorraine; now belongs to the University of Firenze

references to history, collections, or types Giglioli (1886–1907), De Germiny (1936–1938), Violani *et al.* (1984), Poggesi & Buracchi (1990), Voipio (1990)

important past bird staff Carlo Passerini, E. H. Giglioli

important collections come from Bessi, Dainelli, Della Gherardesca, Giglioli coll. (c.4300 skins), Griffoli, Ridolfi, T. Salvadori, Tozzi, Voy. Magenta

approx. nr. of bird skins 18,000 (3,000 species)

other bird items 2,500 skeletons, 300 in alcohol, 350 egg sets, 100 nests

approx. recent annual increase in skins 150, from local birds skinned by own taxidermist, buying of colls., and donations

bird skin collection specialised in Italy, South America, Ethiopia, Somalia, East Africa. Coll. includes skins of 164 extinct and endangered birds

card or computer system present skins partly on card and computer

Frankfurt am Main (SMF for colls, FIS in general)

Info from: D. S. Peters, 17 Jan 1995; update G. Mayr 14 Nov 1999

address Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25, D-60325 Frankfurt am Main 1, Germany

telephone #-49-69-7542348, **fax** #-49-69-746238, **e-mail** gmayr@sug.uni-frankfurt.de

staff responsible for bird coll. Dr Gerald Mayr, Dr D. Stefan Peters (retired, volunteer)

total staff of bird dept. 1 head, 1 secretary, 1–2 others

brief history Founded 1818–1821 by the Senckenbergische Naturforschende Gesellschaft (SNG), but based on older coll. of B. Meyer; still privately owned by SNG

references to history, collections, or types Hartert (1891), Hilgert (1908), Steinbacher (1949, 1954, 1959, 1967), Mertens and Steinbacher (1955), Peters (1992)

important past bird staff E. Rüppell, P. J. Cretzschmar, T. Erckel, A. Koch, O. Kleinschmidt, E. Hartert, C. Hellmayr, H. von Boetticher, J. Steinbacher

important collections come from O. Baron, F. Behn, H. H. C. L. Graf von Berlepsch (donated private coll. of 55,000 skins), G. Cherrie, Döbel, H. Dohrn, C. F. von Erlanger (donated c.12,600 birds), G. W. Freyreiß, G. & O. Garlepp (4,000 birds), J. von Haast, B. Hagen, W. Hoesch, A. von Homeyer (eggs), G. Hopke, H. von Ihering, J. Kalinowski, F. H. von Kittlitz, A. Koch, K. L. Koch, J. S. Kubary, C. F. H. von Ludwig, B. Meyer, E. Peters, G. Radde, B. Schmacker, H. Schubotz, A. Schultze, J. Unger

approx. nr. of bird skins 90,000 (c.6–7,000 species)

other bird items 4,000 skeletons, 3,375 in alcohol, 5,050 egg sets, many fossils

approx. recent annual increase in skin/skeleton coll. 600, from local birds prepared by own taxidermist and buying of colls.

bird skin collection specialised in South America, Germany, northern and eastern Africa, Middle East, Indonesia, New Zealand; Trochilidae

card or computer system present most skins on card (except Trochilidae), spirit and skeleton colls. on computer

Fribourg (MHNF)

Info from: Dr André Fasel, 10 Dec 2001

address Museum d'Histoire Naturelle de Fribourg, Chemin du Musée 6, CH-1700 Fribourg, Switzerland

telephone #-41-26-3009040, **fax** #-41-26-3009760, **e-mail** museehn@fr.ch

staff responsible for bird coll. Dr André Fasel (director) (andre.fasel@ unifr.ch), Emanuel Gerber

total staff of bird dept. —

brief history Founded 1823 with the donation of the coll. of C.-A. Fontaine to the Fribourg Canton; owned by the Fribourg government

references to history, collections, or types Fasel (1998) (history)

important past bird staff C. de Buman, M. Musy, O. Büchi

important collections come from J. de Buman, R. de Boccard, Père A. Buch

approx. nr. of bird skins 5,300 skins (of which 4,800 mounted)

other bird items 1,200 skeletons and skulls, 515 egg sets, and 130 nests

approx. recent annual increase in skins 100–200

bird skin collection specialised in Switzerland, SE China, Vietnam, Ethiopia

card or computer system present Most bird items on computer

Geneva/Genève (MHNGn)

Info from F. J. Baud, 06 Dec 1999

address Museum d'Histoire Naturelle de Genève, Dpt. de Mammalogie et Ornithologie, case postale 6434, CH-1211 Genève 6, Suisse/ Switzerland (visitors address: 1 Route de Malagnou)

telephone #-41-(0)22-4186302, **fax** #-41-(0)22-4186301, **e-mail** francois.baud@ mhn.ville-ge.ch

staff responsible for collection Dr François J. Baud (curator), Dr M. Ruedi (research officer)

total staff of bird dept. 1 head, 2 coll. managers, 2 taxidermist (these for combined bird–mammal dept.; additional staff shared by whole museum)

brief history Founded in c.1850 by the Societé de Physique et d'Histoire Naturelle de Genève; now belongs to the municipality (Ville de Genève)

references to history, collections, or types Baud (1976, 1977, 1978), Weber (1985)

important past bird staff Victor Fatio, T. Horsfield, De Saussure

important collections come from T. Horsfield (Java), W. Parsons (Philippines), K. von Sneidern (Colombia), A. Kovacs (Argentina), A. Vaucher (Trochilidae)

approx. nr. of bird skins 25,000

other bird items c.200 skeletons, 8,500 egg sets, 1,000 bodies in alcohol (of which the skins are in the coll.)

approx. recent annual increase in skins 250, from own expeditions and local bird skinned by own taxidermist

bird skin collection specialised in Switzerland, Java, Philippines, Colombia, Argentina; Trochilidae

card or computer system present Over 60% of skins on computer

Genoa/Genova(MSNG)

Info from: Giuliano Doria, 16 Dec 1999

address Museo Civico di Storia Naturale 'Giacomo Doria', Via Brigata Liguria 9, I-16121 Genova (Genoa), Italy

telephone #-39-(0)10-564 567 or 582 171, **fax** #-39-(0)10-566 319

staff responsible for collection Dr Giuliano Doria

total staff of bird dept. 1 curator (see above, for all animals except insects), 1 taxidermist (for all vertebrates)

brief history Founded in 1867 when the private coll. of Marchese Giacomo Doria was given to City of Genova; still in the possession of the Municipality of Genova

references to history, collections, or types Arbocco *et al.* (1979, 1987), Violani *et al.* (1979, 1984), Capocaccia & Poggi (1982)

important past bird staff A. T. Salvadori (volunteer from Torino, but described 283 new taxa from the coll.)

important collections come from G. Doria, O. Beccari, L.M. D'Albertis, E. Modigliani, L. Loria, O. Antinori, E. Ruspoli, V. Bottego, L. Fea

approx. nr. of bird skins 30,000 (incl mounts)

other bird items 60 mounted skeletons, 400 sterna, 100 jars with many specimens in spirits, 100 egg sets, 100 nests

approx. recent annual increase in skins 30, from donations and local birds skinned by own taxidermist

bird skin collection specialised in Italy, North Africa, Ethiopia, Cape Verde Is. (30 *Alauda razae*!), Gulf of Guinea islands (Príncipe, etc.), Burma, Indonesia, New Guinea. Includes 104 skins of extinct and endangered birds and types or type series of 317 (sub)species.

card or computer system present All on card, none on computer

Glasgow (GLAMG)

Info from: Richard Sutcliffe, 28 Nov 2001

address Glasgow Art Gallery and Museum, Kelvin Grove, Glasgow G3 8AG, U.K.

telephone #-44-141-2872660, **fax** #-44-141-2872690, **e-mail** richard.sutcliffe@cls.glasgow.gov.uk

staff responsible for bird coll. Dr Richard Sutcliffe (Curator of Science)

total staff of bird dept. 1 (for all zoology)

brief history Founded 1870; owned by Glasgow City Council

references to history, collections, or types -

important past bird staff C. E. Palmar, J. MacNaught Campbell, Darryl Mead

important collections come from R. Arbuthnot (eggs), M. A. Black, H. Brown, Major Christie, Capt. H. L. Cochrane, Capt. D. Cross (eggs), P. Hay (eggs), P. Leys, Sir James Lumsden, Col J. M. D. Mackenzie (eggs), W. E. Praeger, J. Ramsay, A. B. Stewart

approx. nr. of bird skins 6,400 (incl. 900 mounts)

other bird items 250 (partial) skeletons, 10,000 eggs, 100 nests

approx. recent annual increase in skins a few only

bird skin collection specialised in Scotland, but also includes quite a number of exotic birds

card or computer system present Most on computer

Görlitz (SMNG)

Info from: Hermann Ansorge, 30 Nov 2001

address Staatliches Museum für Naturkunde Görlitz, Postfach 300154, D-02806 Görlitz, Germany (visitors address: Am Museum 1, D-02826 Görlitz).

telephone #-49-3581-47600/ -4760400, **fax** #-49-3581-4760101, **e-mail** smng.ansorge@t-outline.de

staff responsible for bird coll. Dr Hermann Ansorge (head of vertebrate dept.), Diana Jeschke (taxidermist)

total staff of bird dept. 2 (for entire vertebrate dept: see above)

brief history Founded 1823 as Museum of the Naturforschenden Gesellschaft zu Görlitz, with important enlargement by the donation of the colls. of J. von Zittwitz and H. Boetsscher in 1860–1861.

references to history, collections, or types Ansorge (1987)

important past bird staff J. G. Krezschmar, R. Tobias, J. W. Stolz

important collections come from Niesky Pädagogium, A. R. von Loebenstein (eggs), Vogelschutzwarte Neschwitz

approx. nr. of bird skins 6,800 (incl. 5,500 mounts)

other bird items 1,250 (partial) skeletons, 1,750 egg sets

approx. recent annual increase in skins a few

bird skin collection specialised in worldwide, e.g. with *Ara tricolor*, but primarily the Lausitz area of E Germany

card or computer system present all on card, part on computer

Gothenburg/Göteborg (GNM)

Info from: Göran Nilson, 27 Nov 2001

address Naturhistoriska Museet, Box 7283, S-40235 Göteborg, Sweden (visitors address: Slottsskogen, nr. Linnéplatsen)

telephone #-46-31-7752430, **fax** #-46-31-129807, **e-mail** goran.nilson@gnm.se

staff responsible for bird coll. Göran Nilson

total staff of bird dept. 1

brief history Founded 1833; owned by the local community.

references to history, collections, or types Mathiasson (1985)

important past bird staff Sven Mathiasson

important collections come from K. Kolthoff and others

approx. nr. of bird skins 25,000, incl. 3,548 mounts

other bird items 8,000 skeletons and skulls, 10,000 egg sets, a few birds in alcohol

approx. recent annual increase in skins 100

bird skin collection specialised in Sweden (9,211 skins), remainder exotic; many groups represented, e.g. 250 *Cygnus* spec. All on computer: see www.gnm.se

Grenoble (MHNGr)

Info from: A. Fayard, 9 Jul 2000

address Muséum d'Histoire Naturelle de Grenoble, B.P. 3022, 38816 Grenoble Cedex 1, France (visitors adress: 1, rue Dolomieu)

telephone #-33- (0)4 76 44 05 35, (portable) #-33-(0)6 82 86 92 31, **fax** #-33-(0)4 76 44 65 99, **e-mail** museum-histoire-naturelle@ville-grenoble.fr, **web-site** http://www.ville-grenoble.fr
staff responsible for bird coll. Dr Armand Fayard (head curator), Anne Medard-Blondel (adj. curator)
total staff of bird dept. 1 head, 1 adj. curator, 1 taxidermist, 1 other
brief history Founded in 1847; now owned by Ville de Grenoble
references to history, collections, or types Langrand (1985, 1986a,b)
important past bird staff -
important collections come from Clot-Bey (1842–1844), Bouteille (1847-1881), Vitalis (1899), Bailly (1902), Blanchet (1921), L. Lavauden (1935), Fleurian (1937), L. Léger.
approx. nr. of bird skins 9,000
other bird items 830 eggs, 30 nests
approx. recent annual increase in skins ?, from local birds skinned by own taxidermist, donations, and buying of colls.
bird skin collection specialised in SE France, Tunisia, Egypt (71 mounts of Clot-Bey), Afrotropics (especially Mauritania to Chad), Madagascar (e.g. 269 mounts), etc.
card or computer system present part on a card system, nothing on computer

Halberstadt (MH)

Info from: B. Nicolai, 27 Jun 1996
address Museum Heineanum, Domplatz 37, D-38820 Halberstadt, Germany
telephone #-49-3941-551460, **fax** #-49-3941-551469
staff responsible for bird coll. Dr Bernd Nicolai (head), Rüdiger Holz
total staff of bird dept. 1 head, 2 taxidermists, 1 librarian
brief history Founded in 1830 as private coll. of F. Heine Sr.; the Heine coll. was presented to Stadt Halberstadt in 1907 when A. Hemprich became director
references to history, collections, or types Cabanis, in part with Heine (1850–1863); Busch (1957), Handtke (1974), Kummer (1993), Nicolai (1993), Nicolai *et al.* (1994)
important past bird staff F. Heine Sr., F. Heine Jr., J. Cabanis, C. Müller, F. Tiemann, A. Hemprich, R. Busch, H. von Boetticher, K. Handtke, H. König
important collections come from J. G. W. Brandt, G. A. Frank, M. Hübner (eggs), J. Kummer (eggs), Mus. Berlin (doublets), W. Schlüter, Maison Verreaux, K. Weiß
approx. nr. of bird skins 18,000 (4,500 species)
other bird items 2,000 skeletons, 6,000 egg sets
approx. recent annual increase in skins 100, from local birds skinned by own taxidermist and expeditions
bird skin collection specialised in Germany (3,000 skins), many from a wide scatter of localities elsewhere; Trochilidae (1,800 skins)
card or computer system present all birds received since 1965 on card, none on computer

Halle (IZH)

Info from: Dietrich Heidecke, 26 Nov 2001
address Institut für Zoologie, Zoologische Sammlung, Martin-Luther-Universität, Postfach Universität, D-06099 Halle am Saale, Germany (visitors address: Domplatz 4, D-06108 Halle/S.)
telephone #-49-345-5526455, **fax** #-49-345-5527152, **e-mail** heidecke@ zoologie.uni-halle.de
staff responsible for bird coll. Dr D. Heidecke (Kustos), H.-J. Altner (taxidermist) (both for all vertebrates)
total staff of bird dept. See above
brief history Founded in 1769 as natural history cabinet by J. F. G. Goldhagen, but the oldest birds in existence now are those of C. L. Nitzsch (from about 1815); the coll. increased strongly after the arrival of Burmeister as director in 1837. Now part of the University of Halle-Wittenberg
references to history, collections, or types Taschenberg (1894), Herre (1940), Piechocki (1971) (history); Boetticher (1940) (types); Piechocki (1958, 1968), Piechocki & Bolod (1972), Piechocki *et al.* (1981–1982) (Mongolian and Manchurian colls.)
important past bird staff J. R. Forster, C. L. Nitzsch, K. H. C. Burmeister, C. G. A. Giebel, O. Taschenberg, L. Brühl, L. Ludwig, A. Remane, H. von Boetticher, J. O. Hüsing, R. Piechocki
important collections come from C. L. & A. E. Brehm, Brandt, Brendel, F. W. Junghuhn, G. A. Frank, G. Hartlaub, A. von Humboldt, A. V. Ladygin, J. F. Naumann, R. A. Philippi, W.

Schlüter, M. Schönwetter (19,300 eggs of 3,839 species), M. Stubbe

approx. nr. of bird skins 9,063 (incl. 2,100 mounts of 1,900 species)

other bird items 6,300 (partial) skeletons, 20,000 eggs, over 100 nests

approx. recent annual increase in skins 20–150

bird skin collection specialised in Germany, Mongolia, Kamchatka, NE China, Cuba (over 900 birds), S America (e.g. Chile, Argentina); endangered Palearctic birds of prey, owls, and cranes (esp. skeletons); types of Nitzsch, Burmeister and Giebel

card or computer system present all on card; 60% of skins on computer

Hamburg (ZMH)

Info from: H. Hoerschelmann, Aug. 1996

address Zoologisches Institut und Zoologisches Museum, Universität Hamburg, Martin-Luther-King-Platz 3, D-20146 Hamburg, Germany

telephone #-49-40-4123-3860, **fax** #-49-40-4123-3937, **e-mail** fb6a071@ zoologie.uni-hamburg.de

staff responsible for bird coll. Kordula Bracker, H. Hoerschelmann (retired)

total staff of bird dept. 1 coll. manager, 1 taxidermist

brief history Founded 1843; large parts of the coll. were destroyed in 1943. Now part of University of Hamburg

references to history, collections, or types ?

important past bird staff A. Reichenow, G. H. Martens, H. & H. Bolau, F. Stuhlmann, N. Peters, W. Meise, C. Kosswig, E. Focke

important collections come from F. Dörries, G. A. Fischer, L. Gomez, Hagenbeck Zoo, G. Hartmann, G. Heidemann, G. Heinrich, Heinze *et al.*, D. von Holst, H. Kelm, G. A. von Maydell, Mus. Godeffroy (J. C. Godeffroy; Amalie Dietrich, A. Garrett, E. Gräffe, Capt. Heinsohn, F. Hübner, Th. Kleinschmidt, J. S. Kubary, A. Tetens; types and 'originals' to Hamburg in 1886, duplicates to Bremen), H. Möschler, D. S. Rabor, Prof. Rockstroh, H. Schubotz, A. Schultze, W. Schulz, G. Siemssen, W. Trense, K. Weiß, P. Wyrwich

approx. nr. of bird skins 30,000 (2,500 species)

other bird items 4,000 skeletons, 2,000 in alcohol, 2,000 egg sets, feather-sets of 20,000 birds

approx. recent annual increase in skins 400, from local birds skinned by own taxidermist, buying of colls., and donations

bird skin collection specialised in Germany, São Tomé, Russian Far East, China, Angola, East Africa, India, Pacific, Peru, Guatemala, Philippines, New Guinea, Australia, Bismarck Archipelago; feathers of West Palearctic birds; *Pica pica* (2,000 skins Kelm coll.).

card or computer system present all skins on card; computerising of card system in preparation

Hanover/Hannover (NLMH)

Info from: Chr. Schilling, 21 Feb 2002

address Niedersächsisches Landesmuseum, Naturkunde-Abteilung, Willy-Brandt-Allee 5, D-30169 Hannover, Germany.

telephone #-49-511-9807-827, **fax** #- fax #-49-511-9807-880, **e-mail** naturkunde@ compuserve.com

staff responsible for bird coll. Frau Dr Christiane Schilling (for entire Bioscience coll.)

total staff of bird dept. 1 (see above)

brief history Founded c.1850, owned by Niedersachsen government.

references to history, collections, or types none (but unpublished catalogues for the Kirchhoff and King George colls. available)

important past bird staff —

important collections come from King George V, H. Kirchhoff (formerly in the Göttingen Museum), H. Domeier (originally 40,000 eggs, many from the Neotropics)

approx. nr. of bird skins 9,000

other bird items 75 skeltons, 29,000 eggs, 133 nests

approx. recent annual increase in skins minor acquisitions

bird skin collection specialised in regional avifauna (Niedersachsen), but also from Africa, Asia, and small numbers from South America

card or computer system present all on card, computerisation in preparation

Helsinki (ZMUH)

Info from: Risto A. Väisänen, 17 Nov 1999

address Zoological Museum, Finnish Museum of Natural History, University of Helsinki, P.O. Box 17, FIN-00014 Helsinki, Finland (visitors address: P. Rautatiekatu 13)

telephone #-358-9-1917440, **fax** #-358-9-1917443, **e-mail** risto.vaisanen@helsinki.fi
staff responsible for bird coll. Prof Ann Forstén (head of vertebr. dept), Dr Risto A. Väisänen (senior curator vertebr. dept), Dr Torsten Stjernberg (curator, manager of egg coll.), Pertti Saurola M. Sc. (curator, leader of ringing centre), Martti Hilden M. Sc. (assistant)
total staff of bird dept. 1 head, 3 coll. managers, 1.5 taxidermist, 0.5 others
brief history Originally in University of Turku, where coll. destroyed by fire in 1827; University then moved to Helsinki, where new coll. built up, to which in c.1830–1850 the colls. of the Societas pro Fauna et Flora Fennica and the private coll. of E. J. Bonsdorff were added.
references to history, collections, or types —
important past bird staff A. von Nordmann, M. von Wright, J. A. Palmén, Pontus Palmgren, O. Kalela, P. Voipio, R. Kreuger, G. Bergman, L. Sammalisto
important collections come from Musem Oologicum R. Kreuger (worldwide egg coll.), E. Wassenius (W Palearctic egg coll.)
approx. nr. of bird skins 29,000, incl. mounts (c.2,200 species)
other bird items 1,200 skeletons & skulls, 900 in alcohol, 31,000 egg sets (3,200 species), 800 nests, 800 frozen tissue samples
approx. recent annual increase in skins 600, from local birds skinned by own taxidermist and donation of colls.
bird skin collection specialised in Finland (22,000 skins, mostly rather recent); other skins generally rather old, exotic, partly mounted; eggs (worldwide); birds of prey and owls (esp Finnish *Accipiter*, *Strix*, *Bubo*)
card or computer system present all on card to 1996, all on computer

Karlsruhe (SMNK)

Info from: H.-W. Mittmann, 21 Jan 2002
address Staatliches Museum für Naturkunde, Erbprinzenstraße 13, D-76133 Karlsruhe, Baden-Württemberg, Germany.
telephone #-49-721-1752132, **fax** #-49-721-175211-010, **e-mail** hwmittmann@aol.com
staff responsible for bird coll. Prof. Dr V. Wirth (director), Dr Hans-Walter Mittmann (vertebrate curator)
total staff of bird dept. 1 (for all vertebrates)
brief history Founded c.1785; owned by the government of Baden-Württemberg
references to history, collections, or types —
important past bird staff J. C. Gmelin, H. Knipper, K. Silber
important collections come from Th. Andersen, K. Haberer, B. Hagen, J. Holderer, J. Riedel, J. Unger, Wandres, Zool. Inst. Freiburg
approx. nr. of bird skins 5,000 (incl mounts)
other bird items 300 (partial) skeletons, 600 egg sets, fewer than 50 birds in alcohol
approx. recent annual increase in skins 100–200
bird skin collection specialised in Germany (esp. Baden-Württemberg), C & E Asia, Tanzania, Paraguay, Indonesia (New Guinea)
card or computer system present all items on computer

Kaunas

Info from: Saulius Rumbutis, 20 Dec 1999
address Kaunas Zoological Museum, Laisves aleja 106, LT-3000 Kaunas, Lithuania
telephone#-370-7-200305, **fax** #-370-7-229675, **e-mail** muzzoo@takas.lt
staff responsible for bird coll. Dr Algimantas Macikunas (head), Saulius Rumbutis (ornithologist of bird dept)
total staff of bird dept. 1 head, 1 coll. manager, 2 taxidermists
brief history Founded in 1919 by Prof. Tadas Ivanauskas; owned by the government
references to history, collections, or types J. Vaskelis (1985) *Soobsh. Pribalt. Kom. Izuch. Migr. Ptits* 18: 112-118; Gaidiene (1999) (history); Andriuskevicius & Macikunas (1988) (catalogue).
important past bird staff T. Ivanauskas, K. Bybartas, L. Jezerskas, V. Juska, V. Logmina, V. Mackevicius, M. Navasaitis, B. Talandis, J. Vaskelis
important collections come from L. Ivanauskas
approx. nr. of bird skins 7,630 (828 species)
other bird items 435 skeletons (112 species) and 446 partial skeletons or skulls, 660 birds in spirits (80 species), 872 egg sets, 113 nests.
approx. recent annual increase in skin coll. 37, from own expeditions, buyings and donations, local birds skinned by own taxidermist

bird collection specialised in Lithuania
card or computer system present all on card

Kiel (ZMK)

Info from: Wolfgang Dreyer, 7 Dec 1999.
address Zoologisches Museum der Christian-Albrechts-Universität, Hegewischstraße 3, D-24105 Kiel, Germany
telephone #-49-(0)431-597 4180, **fax** #-49-(0)431-597 4177 , **e-mail** zool/museum@email.uni-kiel.de
staff responsible for bird coll. Dr Wolfgang Dreyer (director of the zoological museum)
total staff of bird dept. 1 head, 1 taxidermist (for entire zoological museum)
brief history Founded 1836; now part of Kiel University. See Hacker (1984)
references to history, collections, or types Catalogue on bird bones in *Arbeitsblätter Univ. Kiel.* 8 (1985), on Dodo and Solitaire bones in *Arbeitsblätter Univ. Kiel* 14 (1987)
important past bird staff W. Behn, K. Möbius
important collections come from F. Boie, G. von Plessen
approx. nr. of bird skins 7,000 (1,950 species)
other bird items 50,000 skeletons; a few egg sets and nests
approx. recent annual increase in skin coll. A few, from local birds skinned by own taxidermist
bird collection specialised in —
card or computer system present all skins on card

Kiev (ZIK or ZMAU)

Info from: Alexander Peklo, 07 Jul 1996
address Zoological Museum, Natural History Museum of the Ukrainian Academy of Sciences, Bogdana Khmelnitskogo Str. 15, 252030 Kiev, Ukraine
telephone #-38-44-2247016
staff responsible for bird coll. Dr Alexander Peklo
total staff of bird dept. 1 curator
brief history Founded in 1919 by V. A. Karavaev of the Ukrainean Academy of Sciences; still part of the Ukrainean Academy of Sciences
references to history, collections, or types Shcherbak (1969), Peklo (1997a,b)
important past bird staff N. Sharleman, A. Kistjakovsky, N. N. Shcherbak, M. Voinstvensky, V. Loskot
important collections come from Y. Kostin, V. Ochapovsky, V. Zubarovsky
approx. nr. of bird skins 40,000 (950 species)
other bird items 120 skeletons, 120 in alcohol, 1,200 egg sets, 600 nests
approx. recent annual increase in skins 30–150, from local birds, own expeditions, buying skins, and donations
bird skin collection specialised in Ukraine, incl. Carpathians and Crimea (over 3,000 skins from latter), Caucasus, Turkmenistan, Transbaikalia, Russian Far East; most of the material quite recent
card or computer system present Catalogue published (see Peklo 1997a,b)

København
see Copenhagen

Krakow (ISEA)

Info from: Z. Bochenski, 25 Sep 1996
address Zaklad Zoologii Systematycznej i Doswiadczalnej (Institute of Systematics and Evolution of Animals), PAN (Polish Academy of Sciences), Ul. Slawkowska 17, PL-31-016 Kraków, Poland [skins & mounts partly housed in Muz. Przyrodnicze ISEZ, PAN, Sw. Sebastiana St. 9, 31-049 Krakow; curator Dr Wieslaw Krzeminski]
telephone #-48-12-227066, ext. 226 (secr.: 221901), **fax** #-48-12-224294
staff responsible for bird coll. Prof. Dr Zygmunt Bochenski, Dr Zbigniew Bochenski (both staff of entire vertebrate division); Dr Teresa Tomek (curator of birds)
total staff of bird dept. Vertebr. section (incl. birds): 1 head, 2 others (see above)
brief history Founded in 1865 as Muzeum Komisji Fizjograficznej Akademii Umiejstnosci w Krakowie; now belongs to Polish Academy of Sciences
references to history, collections, or types Bochenski (1966, 1984, 1990)
important past bird staff K. Jelski
important collections come from Z. Glowacinski, Z. Jakubiec, T. Oles, P. Profus, T. Tomek
approx. nr. of bird skins 1,400, incl. 200 mounts (200 species)

other bird items 3,000 skeletons (1,033 species), 2,900 egg sets, 300 nests
approx. recent annual increase in skins None, but c.150 skeletons annually added, from own taxidermy, exchanges, etc.
bird skin collection specialised in Skins & eggs: Poland, North Korea. Skeletons: worldwide (but esp W Palearctic)
card or computer system present c.1,000 on card; all skeletons on continually updated computer list

Lausanne (MZL)

Info from: Dr Olivier Glaizot, 30 Nov 2001
address Musée Zoologie (MZL), Canton de Vaud, Case postale 448, CH-1000 Lausanne 17, Suisse/ Switzerland (visitors address: Palais de Rumine, Place de la Riponne 6, CH-1005 Lausanne).
telephone #-#-41-21-316-3460, **fax** #--3479, **e-mail** olivier.glaizot@serac.vd.ch
staff responsible for bird coll. Dr Olivier Glaizot (curator for all vertebrates)
total staff of bird dept. See above
brief history Founded late nineteenth century; owned by the Vaud Canton
references to history, collections, or types -
important past bird staff —
important collections come from Capt. Vouga (in 1886), W. Morton, Delessert (eggs)
approx. nr. of bird skins 7,000 (incl. mounts)
other bird items 1,000 (partial) skeletons, 3,000 eggs, fewer than 100 birds on liquid and a few nests
approx. recent annual increase in skins 100, mostly local
bird skin collection specialised in Switzerland (esp. west); historical colls. worldwide
card or computer system present computerisation in progress

Leeds (LEEDM)

Info from: Adrian Norris, 23 Nov 2001
address Leeds Museum Resource Centre, 1 Moorfield Road, Yeadon, Leeds LS19 7BN, U.K.
telephone #-44-113-2146526, **e-mail** adrian.norris@leeds.gov.uk
staff responsible for bird coll. Adrian Norris (Senior Curator of Natural Sciences)
total staff of bird dept. 1 (see above)
brief history Founded in 1819 as the Leeds Philosophical and Literary Society Collections; went to the Leeds City Council in 1921, and still run by this local authority. Partly bombed in 1940–1945
references to history, collections, or types Norris (1998)
important past bird staff -
important collections come from W. T. Crampton (eggs), Eyres-Monsell coll, J. C. Hirst, Sir William Milner, Roundell coll.; Wakefield, Halifax & Swindon Museums
approx. nr. of bird skins 4,500 (incl. 3,500 mounts; an additional 1,000 mounts and many original data of other birds were lost by the damage in 1940–1945)
other bird items 50 (partial) skeletons, 3,000 egg sets
approx. recent annual increase in skins very few
bird skin collection specialised in mounts worldwide, partly historical (mounts in glass cases); includes various rare and extinct species. Eggs from Britain, Europe, Australia and N America
card or computer system present Skins and mounts on computer, but only a minor part of the eggs.

Leiden (RMNH for colls., NNM in general)

Info from: R. Dekker, 19 Mar 1997
address Naturalis, Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA Leiden, the Netherlands (visitors: Darwinweg 2)
telephone #-31-71-5687623, **fax** #-31-71-5687666, **e-mail** dekker@naturalis.nnm.nl
staff responsible for bird coll. Dr René W. R. J. Dekker (head), Hein van Grouw (technical support)
total staff of bird dept. 1 head, 1 coll. manager/ taxidermist
brief history Founded 1815 when the older coll. of C. J. Temminck came to government, with Temminck as first director; now a private institution with governmental support
references to history, collections, or types Gijzen (1938), Stresemann (1951), Holthuis (1995)
important past bird staff C. J. Temminck, C. Reinwardt, H. Boie, H. Schlegel, O. Finsch, J. Büttikofer, E. D. van Oort, G. C. A. Junge, G. F. Mees

important collections come from T. Andersen, M. Bartels (15,000 skins from Java), H. A. Bernstein, A. A. Bruyn, W. Bullock coll./Mus Leverianum (see Vienna/Wien), H. Bürger, K. H. Chen, L. Coomans de Ruiter, D. C. van Dam, P. M. Diard, F. von Faber, E. A. Forsten, G. W. Freyreiß, J. Gilbert, J. Gould, B. Hagen, J. C. van Hasselt, F. Haverschmidt, P. A. Hens, Th. von Heuglin, W. C. & F. C. van Heurn, D. S. Hoedt, A. Hoogerwerf, E. R. Jacobsen, C. Klaesi, Th. Krüper, J. S. Kubary, H. Kuhl, T. Kumlien, J. R. Laenen, F. Levaillant, T. G. van Lidth de Jeude, H. A. Lorentz, H. C. Macklot, S. Müller, A. W. Nieuwenhuijs, J. W. Nouhuys, H. S. Pel, V. von Plessen, F. Pollen, G. van Raalten, L. van Renesse van Duivenbode, J. Riedel, H. von Rosenberg, W. F. H. Rosenberg, E. Rüppell, G. Schlegel, L. A. C. M. Schwaner, W. E. D. Scott, P. F. von Siebold, F. K. Stampfli, R. Swinhoe, J. E. Teysman, E. J. Verreaux, A. G. Vorderman, J. P. van Wickevoort Crommelin

approx. nr. of bird skins 170,000, incl. c.53,000 mounts (in total, 7,000 species)

other bird items 6,673 skeletons, 1,200 in alcohol, 32,571 eggs, c.3,500 nests

approx. recent annual increase in skins 500, from local birds skinned by own taxidermist and buying of colls.

bird skin collection specialised in Indonesia, Japan, Netherlands, E China, Taiwan, Madagascar, Liberia, Tanzania, Kenya, Surinam; over 2,400 types. 37,900 mounts and 41,100 skins of non-passerines, remainder passerines (mainly skins)

card or computer system present c.50% of skins on card; only types & extincts on computer

Leipzig (NKML)

Info from: M. Meyer, 30 Nov 2001

address Naturkundemuseum Leipzig, Lortzingstraße 3, D-04105 Leipzig, Germany

telephone #-47-341-982210, **fax** #-47-341-9822122

staff responsible for bird coll. Dr M. Meyer (curator of vertebrates)

total staff of bird dept. 1 (for entire vertebrate coll., see above)

brief history Founded 1906 by the Naturwissenschaftliche Vereinigung des Leipziger Lehrervereins, opened 1912; from 1930 owned by Stadt Leipzig

references to history, collections, or types —

important past bird staff E. Hesse, E. Pöppig, H. H. ter Meer, etc

important collections come from H. O. Grimm, W. Gueinzius, R. Schlegel (eggs), E. Weiske

approx. nr. of bird skins 6,250 (incl. 2,300 mounts)

other bird items 310 (partial) skeletons, 10 in liquid, 5,000 eggs sets

approx. recent annual increase in skins nil

bird skin collection specialised in Europe; the exotic birds formerly in the coll. were given to the Dresden Museum in the 1970s, but still includes extinct birds like *Pinguinus*, *Nestor productus*, *Heteralochia*, etc.

card or computer system present all on card

Lille

Info from: Roger Marcel, 27 Dec 1999

address Musée d'Histoire Naturelle de Ville de Lille, 19 Rue de Bruxelles, 59000 Lille, France.

telephone #-33-(0)3-285530380 **fax** #-33-(0)3-20861482

staff responsible for bird coll. Dr Roger Marcel (conservateur universitaire), Bertrand Rodigois (coll. manager)

total staff of bird dept. See above

brief history Founded in the mid-1850s when the coll. of Degland was obtained by the Lille Municipality; still owned by the Ville de Lille

references to history, collections, or types Only Degland's catalogue available, printed 1857

important past bird staff A. Bart

important collections come from C. D. Degland, coll. Vilmarest-de Cossette

approx. nr. of bird skins 11,000 (incl. many mounts)

other bird items very few, and without scientific interest

approx. recent annual increase in skins c.50, from various sources

bird skin collection specialised in Europe (especially France) (c.5,000 birds from the colls. Degland and Vilmarest), also, 6,000 birds from elsewhere in the world, but largely without full locality data

card or computer system Degland coll. on card & computer, cataloguing of Vilmarest coll. in prep.

Linz

Info from: G. Aubrecht, 6 Dec1999

address Biologie Zentrum des Oberösterreichisches Landesmuseums, Johann-Wilhelm-Klein-Straße 73, A-4040 Linz-Dornach, Österreich/ Austria.

telephone #(0)723-759733-57, **fax** #(0)732-759733-99, **e-mail** g.aubrecht@landesmuseum-linz.ac.at

staff responsible for bird coll. Dr Gerhard Aubrecht (zoologist), Mag. Stefan Weigl (zoologist, head of taxidermist laboratory), Jürgen Plass (coll. manager)

total staff of bird dept. see above; also, 1 taxidermist & 1 secretary

brief history Founded 1833 as Museum of Upper Austria (a private society), now owned by Government of Upper Austria

references to history, collections, or types Kerschner & Schadler (1933), Lindorfer (1970), Aubrecht & Mayer (1983), Aubrecht (1987, 1995)

important past bird staff A. Reischek, T. Kerschner, G.Th. Mayer

important collections come from A. Reischek (but most went to Vienna), T. Angele (1,500 specimens, incl. coll. A. G. H. Rudatis from Natal), G. Wieninger (e.g. Paraguay), J. Lindorfer (eggs)

approx. nr. of bird skins 8,200 (incl 3,600 mounts), c.1,000 species

other bird items a few skeletons, 160 skulls, 3,400 egg sets (360 species), 450 nests, feathers and pluckings of c.220 birds

approx. recent annual increase in skins c.100, from local birds skinned by own taxidermist and buying of colls.

bird skin collection specialised in Upper Austria, New Zealand, Natal, Paraguay; raptors and owls.

card or computer system All until 1990s on card; all skins, the Angele coll., and birds received since 1990 are on computer (in the ZOBODAT system), making geographical grouping and plotting on maps easier

Lisbon/Lisboa (MB)

Info from: C.Almaça, 03 Apr 1997, updated C. Hazevoet, 27 Mar 2002

address Museu Bocage, Fac. de Ciências, Rua da Escola Politécnica 58, P-1200 Lisboa, Portugal

telephone #-351-1-3965853 or 604485, **fax** #-351-1-3969784, **e-mail** calmaca@fc.ul.pt, hazevoet@fc.ul.pt

staff responsible for bird coll. Dr Maria da Graça Ramalhino (head of vertebrate section), Dr Carlos Almaça (director of Museum), Dr C. J. Hazevoet (bird dept.)

total staff of bird dept. 1 head, 1.5 taxidermist, 0.5 secretary, 1 other (all for entire vertebr. section)

brief history Founded in 1772 by Domingos Vandelli as Real Museu e Jardim Botanîco da Ajuda; now belongs to the University of Lisboa. A fire destroyed the entire coll. in March 1978, but it is now gradually being built up again

references to history, collections, or types Before the fire of 1978: Soares (1970, 1971, 1973, 1977); after the fire: Soares (1983), Almaça (1987, 1993, 1994, 1996), Almaça & Neves (1987)

important past bird staff J. V. Barbosa du Bocage, G. F. Sacarrão, A. A. Soares

important collections come from several old ones, but destroyed by fire (see above)

approx. nr. of bird skins 2,500 (at present; see above), 250 species

other bird items a few eggs and nests

approx. recent annual increase in skins 100, from local birds skinned by own taxidermist

bird skin collection specialised in Originally, many birds from Angola, Mozambique, Portugal, etc. After the fire, a coll. of birds of Portugal is being made again, with some additional birds present from Madeira and São Tomé

card or computer system present All on card and computer; the card system for the coll. destroyed by fire is still in existence

Lisbon/Lisboa (CZ/IICT)

Info from: J. Crawford-Cabral, 07 May 1997

address Centro de Zoologia, Instituto de Investigação Científica Tropical, Rua da Junqueira 14, P-1300 Lisboa, Portugal

telephone #-351-1-3637055, **e-mail** czool@www.iict.pt

staff responsible for bird coll. Dr Luis Mendes (curator), Pedro Santos (head, higher vertebrate colls.), Maria José Teixeira (coll. manager)

total staff of bird dept. see above (for entire vertebrate section)

brief history Founded as Junta das Missões Geográficas e de Investigações Coloniais in 1936, which organised expeditions; to keep the colls., the Centro de Zoologia was founded in 1948; a governmental institution

references to history, collections, or types Rosa Pinto (1983), de Naurois (1994 a,b) [books based on the colls. of the CZ/IICT]

important past bird staff F. Frade, João Crawford-Cabral

important collections come from Missão Científica de S. Tomé (1954–1956), Missão de Estudos Zoológicos do Ultramar (1963–1970), Missão Zoologíca da Guiné 1944–1946, Missão Zoologíca de Moçambique 1948 & 1955, R. de Naurois, A. A. da Rosa Pinto, G. Stein

approx. nr. of bird skins 6,340 (1,120 species)

other bird items 250 in alcohol, 110 eggs, a few nests

approx. recent annual increase in skins 0

bird skin collection specialised in Cape Verde Islands (600 skins, 55 spec.), Guinea Bissau, São Tomé and Príncipe, Mozambique, Goa, Macau, Timor

card or computer system present all skins on card system; computerisation planned

Liverpool (LivCM)

Info from: C. T. Fisher, July 1996

address Liverpool Museum, National Museums & Galleries on Merseyside, Dept. of Vertebrate Zoology, William Brown Street, Liverpool L3 8EN, U.K.

telephone #-44-151-207-0001, **fax** #-44-151-478-4390

staff responsible for bird coll. Dr Clemency T. Fisher (curator of birds & mammals), Tony Parker B. Sc. (ass. curator vertebrates), Dr Malcolm J. Largen (herpetologist, but occasionally also birds)

total staff of bird dept. 3 scientists, 2 taxidermists, 2 others (all partly working on other groups)

brief history Founded 1851 when the large and much older private coll. of Lord Stanley (the 13th Earl of Derby) was presented to the City of Liverpool; now funded by the government (formerly by the Merseyside County Council)

references to history, collections, or types Wagstaffe (1978), Fisher (1981), Cowper (1984), Largen & Rogers-Price (1985), Largen (1987, 1988), Woolfall (1990)

important past bird staff T. J. Moore, H. O. Forbes, L. Fraser, E. Lear, H. G. Robinson, R. Wagstaffe, P. J. Morgan

important collections come from J. Abbot, T. Ayres, Bates, T. Bridges, W. E. Brooks, W. Buller, W. Bullock coll. (see Vienna/Wien), J. Burke, W. D. Cowan, H. Cuming, W. R. Davison, H. O. Forbes, L. Fraser, W. T. & E. Gerrard, J. Gilbert, J. Gould, J. H. Gurney, G. Henderson, India Mus., W. Jardine, T. C. Jerdon, F. H. Kirby, J. Latham, C. L. & E. L. Layard, J. Leadbeater, J. MacGillivray, L. Mandelli, Mus. Godeffroy, Rev. Inglis, Mus. Leverianum (see Vienna/Wien), E. W. Oates, R. C. L. Perkins, H. Pryer, P. Rendell, G. E. Richards, W. Rowan, H. Salt, O. Salvin, St. Helen's Mus., A. Smith, Lord Stanley (Earl of Derby) coll. (over 20,000 skins), W. Swainson, R. Swinhoe, H. B. Tristram coll. (over 17,000 skins; another 7,000 to Philadelphia), Verreaux, Voy. Beagle, A. R. Wallace, Webster-Harris exp., Whitfield, S. Whitmee, A. Whyte, J. G. Williams

approx. nr. of bird skins 48,192, excl. 3,367 mounts (5,700 species)

other bird items 700 skeletons, 12,000 egg sets, 180 nests

approx. recent annual increase in skins 50, from local birds skinned by own taxidermist, buying of colls., and donations

bird skin collection specialised in 'strong in all areas and families'; Tristram coll. especially strong in Middle East, North Africa, Canary Is., Bermuda, eastern USA, Pacific, Japan, etc.

card or computer system present All items on card and all on computer (except part of eggs), available in various arrangements (Dbase III)

Lund (ZMUL)

Info from: L. Cederholm, Aug. 1996

address Zoologisk Museum, Universitet fran Lund, Helgonavägen 3, S-22362 Lund, Sweden

telephone #-46-46-222-9330, **fax** #-46-46-222-4541, **e-mail** zool@zool.lu.se

staff responsible for bird coll. Prof Sven-Axel Bengtson (head of entire museum)

total staff of bird dept. 0.5 taxidermist

brief history Founded 1735; now part of the University of Lund

references to history, collections, or types Löwegren (1968)

important past bird staff Sven Nilsson, G. Rudebeck, Yngve Löwegren, Lennart Cederholm
important collections come from —
approx. nr. of bird skins 20,000
other bird items 1,000 skeletons, 800 in alcohol, 2,000 tissue samples, 8,393 egg sets, 400 nests
approx. recent annual increase in skins 300–2,000, from local birds skinned by own taxidermist
bird skin collection specialised in Sweden
card or computer system present all skins and mounts on computer

Lviv (Lvov)

Info from: Ihor Shydlovskyy, 4 Jan 2000
address Benedykt Dybowsky Zoological Museum of the Ivan Franko Lviv National University, Hrushevsky Str. 4, 79005 Lviv, Ukraine
telephone #-380-(0)322-794 548, **fax** #-, **e-mail** zoomus@frank.lviv.ua, **website** http://www.carpathian.uar.net/museum/ or http://ecocarpathian. uar.net/museum/
staff responsible for bird coll. Ihor Shydlovskyy
total staff of bird dept. See above (head of entire museum as well as taxidermist); also, staff present of the West-Ukrainian Ornithological Station WUOS
brief history Founded 1885, but includes material of the Lvov Cabinet of Natural History, dating from 1823; now part of the University
references to history, collections, or types Catalogue of rare and endangered animals: Tsaryk (2000); oological catalogue is in preparation
important past bird staff B. I. Dybowsky, F. I. Strautman, N. A. Srebrodolska, A. Ulianovsky, Z. I. Pavliv, I. I. Hladunko, I. Gorban
important collections come from —
approx. nr. of bird skins 3,500 (incl. 1,604 mounts)
other bird items 476 egg sets, 55 nests, a few skeletons and spirit specimens
approx. recent annual increase in skins 20–25, from own expeditions and local specimens
bird skin collection specialised in Ukraine, but also quite a number of exotic species (120 families represented)
card or computer system present in preparation

Madrid (MNCN)

Info from: J. Barreiro, 02 Sep 1996 & 11 Nov 2001
address Museo Nacional de Ciencias Naturales (Consejo Superior de Investigaciones Cientificas CSIC), José Gutiérrez Abascal, 2, E-28006 Madrid, Spain
telephone #-34-91-411-1328, **fax** #-34-91-564-5078, **e-mail** jbarreiro@mncn.csic.es
staff responsible for bird coll. Ms Josefina Barreiro (curator of birds and mammals), Dr Eulalia Moreno (researcher Ecologia Evolutiva dept.), Dr P. Alberch (general director)
total staff of bird dept. 1 coll. manager, 1.5 taxidermist, 0.4 other (for birds and mammals)
brief history Founded in 1771 when King Carlos III obtained the colls. of Pedro Franco Dávila; now part of the Vicedirección de Colecciones y Documentación of CSIC, a governmental organisation
references to history, collections, or types Barreiro (1997), Barreiro & Pérez del Val (1998)
important past bird staff A. Gil Lletget, F. Bernis
important collections come from A. Boucard, P. Franco Dávila (obt. 1771; no birds left now), Exped. Pacifico 1862–1866
approx. nr. of bird skins 19,000 (1,000 species)
other bird items 6,000 skeletons, 1,900 in alcohol, 1,500 egg sets, 235 nests
approx. recent annual increase in skins 200 (mainly to skeleton or alcohol coll.), from local birds skinned by own taxidermist and donations
bird skin collection specialised in Spain (9,300 skins), Morocco (965), C & S America (4,452: esp Chile, Colombia, Mexico, Ecuador, Brazil, Guatemala, Cuba, Panama, Peru), Philippines (524), Eq. Guinea (503), Zaire (462), Japan (281), China (247), Indonesia (151), India (132), Australia (116); Trochilidae (1,749), Accipitridae (1,480), Emberizidae (1,318), etc. 2 types. Most birds from 1880–1930
card or computer system present part of skins on card system, all on computer

Magdeburg (MfNM)

Info from: H. Pellmann, 28 Nov 2001

address Museum für Naturkunde Otto-von-Guerickestraße 68-73, D-39104 Magdeburg, Germany.

telephone #-49-391-5403501

staff responsible for bird coll. Dr Hans Pellmann (for all vertebrates)

total staff of bird dept. 1 (see above)

brief history Founded 1874; owned by the city of Magdeburg

references to history, collections, or types Krüger (1925) (history, catalogue)

important past bird staff —

important collections come from —

approx. nr. of bird skins 6,200

other bird items 1,200 egg sets

approx. recent annual increase in skins 10–50

bird skin collection specialised in Magdeburg and surrounding state of Sachsen-Anhalt; also from elsewhere in Germany, as well as various Palearctic and exotic birds

card or computer system present All on card; catalogue in preparation

Manchester (MANCH)

Info from: M. Hounsome, 03 Apr 1997

address The Manchester Museum, University of Manchester, Oxford Road, Manchester M13 9PL, U.K.

telephone #-44-161-275-2673, **fax** #-44-161-275-2676, **e-mail** m.hounsome@man.ac.uk

staff responsible for bird coll. Dr Michael V. Hounsome (Keeper of Zoology)

total staff of bird dept. 1 head, 1 part-time technician, 2 volunteers

brief history Founded in 1821 by the Manchester Society of Natural History, now owned by the University of Manchester

references to history, collections, or types For catalogue, see Internet page

important past bird staff R. B. Sharpe, H. E. Dresser, Coward

important collections come from H. E. Dresser coll. (15,000 birds, obtained 1896, and many eggs, obtained 1906)

approx. nr. of bird skins 16,500, incl. 400 mounts (3,500 species)

other bird items 100s of skeletons, 50 in alcohol, 10,000 egg sets (of 3,000 species), 50 nests

approx. recent annual increase in skins 50, from local birds skinned by own taxidermist, own expeditions, buying of colls., and donations

bird skin collection specialised in 'worldwide, but especially Palearctic; all families'

card or computer system present part of skins on card, all on computer, available at web page: see http//www.man.ac.uk/museum

Milan/Milano (MSNM)

Info from: G. Chiozzi, 11 May 1995, updated 13 Nov 1999

address Museo Civico di Storia Naturale, Corso Venezia, 55, I-20121 Milano, Italy

telephone #-39-02-781312, **fax** #-39-02-7602-2287, **e-mail** giorgio_chiozzi@hotmail.com

staff responsible for bird coll. Dr Giorgio Chiozzi (head), Dr Luigi Cagnolaro (head dept. vertebr. zool.)

total staff of bird dept. 0.1 head, 1 coll. manager, 1 taxidermist

brief history Founded in 1831 by G. De Cristoforis & G. Jan, but only a few birds were included until 1884; part of coll. destroyed in 1943; owned by the Municipality of Milano

references to history, collections, or types Violani *et al.* (1984), Violani (1985), Chiozzi (1993)

important past bird staff Edgardo Moltoni

important collections come from L. D'Albertis, O. Beccari, A. A. Bruijn, Emin Pasha, J. Hildebrandt, L. Laglaize, Capt. Loche, A. Malherbe, H. Möschler, A. B. Meyer, T. Salvadori, G. Scortecci, Count E. Turati private coll. (20,661 skins, 700 skeletons, 3,000 eggs), Maison Verreaux

approx. nr. of bird skins 34,000

other bird items126 skeletons, 1,000 skulls & keels, 2,500 eggs

approx. recent annual increase in skins 100, purchased from private taxidemists

bird skin collection specialised in Italy, Palearctic, Algeria, NE Africa, Comoros, Madagascar, S America; Charadriiformes, Picidae, Trochilidae, Paradisaeidae, Passeriformes. Includes 124 skins of extinct and endangered birds

card or computer system present small parts of the coll. on card and computer

Moscow/Moskva (ZMMU)

Info from: P. Tomkovich, 15 Mar 1995, updated by M. Kalyakin, 26 Jan 2000 & 11 Nov 2001

address Zoological Museum, Orn. dept., Moscow Lomonosov State University (Zoologicheskii Muzei MGU), Bolshaya Nikitskaya Str. 6, 103009 Moscow (Moskva), Russia

telephone #-7-95-203-4366, **fax** #-7-95-203-2717, **e-mail** tomkovic@1.zoomus.bio.msu.ru, kalyakin@rambler.ru

staff responsible for bird coll. Dr Pavel Tomkovich (head), Dr Eugene A. Koblik (specialised in Emberizidae and fauna of former USSR), Dr Mikhail V. Kalyakin (specialised in Sylviidae, Pycnonotidae, anatomy, and fauna of Vietnam)

total staff of bird dept. 1 head, 2 scientific coll. managers, 2 taxidermists

brief history Restarted in 1812 by J. G. Fischer von Waldheim after a fire had destroyed the older museum in the Napoleontic War; part of Moscow State University

references to history, collections, or types Bogdanov (1892), Turov (1956), Sudilovskaya (1959, 1962, 1972, 1977), Tomkovich & Barisheva (1987), Rossolimo (1991)

important past bird staff J. G. Fischer von Waldheim, M. N. Bogdanov, M. A. Menzbier, S. A. Buturlin, S. I. Ognev, G. P. Dementiev, N. A. Gladkov, S. M. Uspenskii, E. P. Spangenberg, A. M. Sudilovskaya, S. S. Turov

important colections were obtained from or presented by V. N. Bostanzhoglo (Bostanjolo), P. G. Demidov, V. E. Flint, V. E. Fomin, V. A. Khakhlov, A. P. Kuzyakin, G. Baron von Langsdorf, V. V. Morozov, G. I. Polyakov, N. A. Severtzov, S. S. Turov

approx. nr. of bird skins 117,000 (1,500 species)

other bird items 2,000 skeletons, 3,000 in alcohol (500 species), 8,500 egg sets (often with the nests) (600 species)

approx. recent annual increase in coll. 500–600 items (skins, egg sets, etc), from expeditions, donations, and local birds skinned by own taxidermist

bird skin collection specialised in Former Soviet Union (especially the NE), Mongolia, N & W China, Vietnam, Brazil, Japan, USA; birds of prey, waders, gulls, owls, passerines (e.g. Paridae); 300 types

card or computer system present all skins and most egg sets & nests on card, only types on computer

Moscow/Moskva (SDM)

Info from: E. Nesterov, 16 Jul 1996

address Darwin Museum, Vavilova Street 57, 117292 Moskva, Russia

telephone & fax #-7-95-135-33-76, **e-mail** jennest@darwin.museum.ru

staff responsible for bird coll. Dr Eugene V. Nesterov (head), Igor V. Fadeev (curator)

total staff of bird dept. 1 head, 1 curator, 1 secretary

brief history Founded in 1907 by Prof. A. F. Koths; government-owned

references to history, collections, or types Fadeev (1999)

important past bird staff —

important collections come from G. P. Dementiev, M. N. Divnogorskii, V. A. Khakhlov, A. M. Khomyakov, A. P. Kuzyakin, F. K. Lorentz, M. A. Menzbier, E. P. Spangenberg, P. P. Sushkin

approx. nr. of bird skins 11,000 (1,500 species)

other bird items 50 skeletons, 1,000 egg sets, 150 nests

approx. recent annual increase in skins 150, from local birds skinned by own taxidermist, expeditions, donations, and from zoos & customs

bird skin collection specialised in worldwide; all families, especially Tetraonidae, Anatidae, Trochilidae; incl. *Pinguinus impennis & Ectopistes migratorius*

card or computer system present all skins on card and computer

Moscow/Moskva (PIN RAS)

Info from: Y. Kurochkin, 10 Feb 2000

address Laboratory of Paleoherpetology and Paleo-ornithology, Institute of Paleontology, Russian Academy of Sciences, 123 Profsouznaya Streeet, 117868 Moscow GSP-7, Russia

telephone #-7-95-339-6988, **fax** #-7-95-339-1266, **e-mail** enkur@paleo.ru

staff responsible for bird coll. Dr Yevgeny N. Kurochkin (head), Dr Aleksandr Karhu

total staff of bird dept. See above.

brief history Founded 1962 by the Russian Academy of Sciences

references to history, collections, or types none (but see Wood *et al.* 1982)

important past bird staff —

important collections come from —

approx. nr. of bird skins none, but 5,000 bird skeletons (1,500 species)

other bird items 70 in alcohol

approx. recent annual increase in skeleton coll. 100, from own expeditions and zoo specimens

bird collection specialised in skeletons

card or computer system present all skeletons on card, part on computer

Munich/München (ZSM)

Info from: J. H. Reichholf, 07 Apr 1997, some add. F. Steinheimer, Aug 2002

address Zoologische Staatssammlung, Münchhausenstrasse 21, D-81247 München, Germany

telephone & fax #-49-89-8107-123 (81070: general)

staff responsible for bird coll. Prof Dr Josef H. Reichholf (head of bird department), Ms Ruth Diesener (ass.)

total staff of bird dept. 1 head, 1 technical assist., 1 taxidermist

brief history Founded in 1759 as private coll. of Kurfürst Maximilian III Joseph von Bayern, but real growth only after arrival of von Spix in 1807, and again, after a 60-year gap in bird activity, with C. E. Hellmayr in 1903; now belongs to the Bayern government

references to history, collections, or types Hellmayr (1928), Reichholf (1983)

important past bird staff J. B. von Spix, J. Wagler, A. Wagner, F. Doflein, K. Parrot, H. Sachtleben, E. Zugmayer, C. Hellmayr, C. Zimmer, A. Laubmann, G. Diesselhorst

important collections come from G. von Almásy, T. Andersen, Princes Therese von Bayern, Canesi, Comte R. de Dalmas, K. Deniger, H. Dürck, Exp. Filchner, A. Fischer, J. Gengler, J. von Haast, K. Haberer, J. Haffer, B. Hagen, J. C. van Hasselt, Haverschmidt, Keerl, S. M. Klages, K. L. Koch, H. Krieg, H. Kuhl, Kunkel, priv. coll. A. Laubmann (6,000 skins), M. von Leuchtenberg, F. Leybold, L. Martin, G. Merzbacher, K. Michahellis, L. Müller, J. Natterer, O. Neumann, Neunteufel, M. W. Palmer, Popp, M. Prager, G. Radde, J. Riedel, A., H. & R. Schlagintweit, R. Schlegel, W. Schlüter, J. von Seilern, Ph. F. von Siebold, Lt. Sommerfeld, E. Stechow, E. Stresemann, J. H. C. F. & J. W. Sturm, O. Tauern, R. von Thanner, V. von Tschusi, H. & C. Watkins, H. Weigold, L. von Wiedenfeld

approx. nr. of bird skins 60,000 (6,000 species)

other bird items almost nil

approx. recent annual increase in skins 50, from local birds skinned by own taxidermist, donations, customs, etc.

bird skin collection specialised in Germany (Bavaria, Pfalz), Corsica, Lithuania, Hungary, Macedonia, Asia Minor, Iraq, Caucasus area, C Asia (W Tibet, Tien Shan, Baluchistan, Nepal), Sri Lanka, E China, Japan, Kuril Is, Indonesia (e.g. Sumatra, Bangka, Timor, Buru, Misol), NE New Guinea, Senegambia, Tanzania, Mexico, Galapagos, South America (Colombia, Venezuela, Trinidad, Brazil, Peru), etc.; over 400 types

card or computer system present part of skins on card, none on computer

Münster (WMN)

Info from: H Terlutter, 30 Nov. 2001

address Westfälisches Museum für Naturkunde, Sentruper Straße 285, D-48149 Münster, Germany

telephone #-49-251-5916014, **e-mail** h.terlutter@lwl.org

staff responsible for bird coll. Dr Heinrich Terlutter

total staff of bird dept. 1

brief history Founded 1872 by Bernard Altum, F. von Droste-Hülshoff, and H. Landois, opened 1874, considerably enlarged in 1891 and after the arrival of Rensch in 1937; owned by Landschaftsverband Westfalen-Lippe

references to history, collections, or types Franzisket (1967)

important past bird staff F. von Droste-Hülshoff, H. Landois, R. Koch, H. Reeker, H. Reichling, B. Rensch, L. Franzisket

important collections come from L. zu Salm-Salm, A. Tenckhoff (eggs)

approx. nr. of bird skins 6,000

other bird items 20 (partial) skeletons, 600 egg sets, 100 nests

approx. recent annual increase in skins 100

bird skin collection specialised in NW Germany
card or computer system present In preparation

Nantes (MHNNT)

Info from: François Meurgey, 29 Jan 2002
address Museum d'Histoire Naturelle de Nantes, 12 rue Voltaire, F-44000 Nantes, France
telephone #-33-2-40-992620/ 992627, **fax** #-33-2-40-51840191, **e-mail** François.Meurgey@mairie-nantes.fr
staff responsible for bird coll. Dr François Meurgey
total staff of bird dept. —
brief history Founded nineteenth century; belongs to municipality of Nantes
references to history, collections, or types Marchand & Kowalski (1903), Durand (1961), Recorbet (1991)
important past bird staff Louis Bureau, J. Kowalski
important collections come from Blandin, Bonjour, Vian
approx. nr. of bird skins 22,100
other bird items 108 (partial) skeletons, 8,757 egg sets, 365 feather sets, 124 nests
approx. recent annual increase in skins fewer than 10
bird skin collection specialised in W France, but also birds from elsewhere in Europe and from Africa and Asia.
card or computer system present All on computer (Taurus database)

Neuchâtel (MHNNL)

Info from: B. Mulhauser, 26 Nov 2001
address Muséum d'Histoire Naturelle de Neuchâtel, Rue des Terreaux 14, CH-2000 Neuchâtel, Switzerland
tel. #-41-32-7177960, **fax** #-41-32-7177969, **e-mail** blaise.mulhauser @mhnn.unine.ch
staff responsible for bird coll. Dr Blaise Mulhauser (curator of all vertebrates)
total staff of bird dept. 1 (see above)
brief history Founded 1835, but based on older coll. of C. D. de Meuron presented to the city in 1795); owned by the city of Neuchâtel
references to history, collections, or types Dufour & Haenni (1985) (history), Desfayes (1994) (data on 91 types of Tschudi from Peru)
important past bird staff L. Coulon, P. Godet, Louis Agassiz, M. Desfayes
important collections come from J. J. von Tschudi, A. Mathey-Dupraz, F. Gehringer, S. Robert (eggs),
approx. nr. of bird skins 10,000 (3,200 species)
other bird items 200 (partial) skeletons, 6,000 eggs, 200 nests
approx. recent annual increase in skins 30
bird skin collection specialised in Switzerland, Europe generally, N USA (Agassiz), C & S America (esp. Peru: Tschudi), Australia; incl. 91 types and 24 paratypes from Tschudi and c.13 types from other authors
card or computer system present —

Newcastle (NEWHM)

Info from: L. Jessop, 07 Apr 1997
address The Hancock Museum, Barras Bridge, Newcastle upon Tyne, Tyne & Wear NE2 4PT, U.K.
telephone #-44-191-222-7418, **fax** #-44-191-222-6753, **e-mail** hancock.museum@ncl.ac.uk
staff responsible for bird coll. A. Coles (curator of entire biology and geology coll.), L. Jessop (keeper of biology [incl. birds]), E. Morton (ass. keeper biology)
total staff of bird dept. Fewer than 1: see above (no one specifically dedicated to bird coll. only)
brief history Founded c.1760–1770 as private coll. of Marmaduke Tunstall; coll. went to Newcastle in 1822, and belongs to the Natural History Society of Northumbria since the latter was founded in 1829
references to history, collections, or types Howse (1899)
important past bird staff John Hancock, Thomas Bewick
important collections come from Herb. Stevens
approx. nr. of bird skins 12,000, incl. 2,000 mounts
other bird items 200 skeletons, 10 in alcohol, 10,000 egg sets, 1,000 nests
approx. recent annual increase in skins 10, from own taxidermy
bird skin collection specialised in Great Britain; India (Stevens coll., 4,050 skins, received 1965); also, some types and 8 extinct or endangered birds (catalogue of rarer birds in prep.)

card or computer system present all skins on computer; mounts not catalogued

Oslo (ZMUO)

Info from: J. Lifjeld, 12 Nov 1999

address Zoologisk Museum, Sars gate 1, N-0562 Oslo, Norway

telephone #-47-22851726, **fax** #-47-22851837, **e-mail** j.t.lifjeld@toyen.uio.no

staff responsible for bird coll. Dr Jan T. Lifjeld

total staff of bird dept. 2

brief history —

references to history, collections, or types Ore & Høeg (1961) (history)

important past bird staff R. Collett, Edvard K. Barth, R. Vik, Gunnar Lid, T. Slagsvold

important collections come from A. Bernoft-Osa, Y. Hagen, C. Lumholtz, Ø. Olsen, H. T. L. Schaanning, J. Koren, J. Thome

approx. nr. of bird skins 25,000, incl. 2,000–4,000 mounts

other bird items 1,000 skeletons, 500 in spirit, 6,500 egg sets, 5,000 tissue samples

approx. recent annual increase in skins 50–100

bird skin collection specialised in Norway, Australia, Borneo, Antarctica, Siberia, Svalbard, Tristan da Cunha

card or computer system present Skins, eggs, and tissue samples on computer

Oxford (OUM)

Info from: J. Pickering, 1996

address Zoological Collections, Oxford University Museum, Parks Road, Oxford OX1 3PW, U.K.

telephone #-44-1865-272950, **fax** #-44-1865-272970

staff responsible for bird coll. Dr Tom Kemp (curator of the zoological colls.), Jane Pickering M.Sc. (assistant curator of birds)

total staff of bird dept. 0.5 head, 1 ass. curator, 1 technician

brief history Founded in 1683 as private coll. of J. Tradescant when the Ashmole coll. arrived in Oxford; coll. came to Oxford University in 1860

references to history, collections, or types Davies & Hull (1976, 1983)

important past bird staff 'many'

important collections come from O. V. Aplin, Sir John Barrow, W. J. Burchell, C. & E. Hose, F. P. Pascoe, H. S. Rohu, S. W. Silver, R. H. Thomas, W. H. Treacher, C. M. N. White

approx. nr. of bird skins 19,000 ('many species')

other bird items 1,500 skeletons, 500 in alcohol, 2,000 egg sets

approx. recent annual increase in skins 20, from donations

bird skin collection specialised in Britain, South Africa, Borneo, Sulawesi, New Guinea, Ecuador, Brazil, Arctic, New Zealand

card or computer system present all skins on card, none on computer

Paris (MNHN)

Info from: E. Pasquet, 07 May 1997, updated 14 Nov 1999

address Muséum National d'Histoire Naturelle, Laboratoire de Zoologie, dep Mammifères et Oiseaux, 55 Rue de Buffon, F-75005 Paris, France

telephone #-33-1-40793062, **fax** #-33-1-40973063, **e-mail** pasquet@mnhn.fr, lefevre@mnhn.fr

staff responsible for bird coll. Eric Pasquet (curator of bird coll.), Christine Lefevre (curator of skeletons), Géraldine Veron, C. Voisin, J.-F. Voisin, C. Jouanin (volunteer associate)

total staff of bird dept. See above; also 1 technician, 1 taxidermist, 1 secretary (for Dept. of Birds & Mammals), 1 librarian (for entire Zoology Lab.)

brief history Founded in 1793, when the older colls. of Réaumur, Brisson, and the Cabinet du Roi went to the Muséum d'Histoire Naturelle; owned by the French government

references to history, collections, or types Berlioz (1929, 1935, 1950), Jouanin (1951, 1962), Voisin (1992, 1993, 1995)

important past bird staff G.-L. Buffon, F. Cuvier, J. Verreaux, R. P. Lesson, E. & I. Geoffroy de St Hilaire, A. Milne-Edwards, E. Oustalet, A. Ménégaux, J. Berlioz, R. D. Etchécopar, J. Dorst, F. Roux

important collections come from G. Babault, N. Baudin, J. A. Bernier, G. Bonvalot, A. Boucard, J. Bourcier, Maison Bouvier, W. Bullock coll./Mus. Leverianum (see Vienna/Wien), M. J. Brisson, A. A. Bruijn, Père Armand David, A. David-Beaulieu, Jean Delacour, P. A. Delalande, P. M. Diard, L. Dufresne, J. Dumont d'Urville, L. Duperrey, Maison Dupont, A. Duvaucel, P. Engelbach, L. Freycinet, J. P. Gaimard, P. Garnot, J. B. Hombron, P. Jabouille, C. & H. Jacquinot, Baron Meiffren Laugier, J. Leschenault de la Tour, F. Levaillant, Marche, R. Maugé de Cely, H. Möschler, R. de Naurois, A. Néboux, Prince Henri d'Orléans, Maison Parzudaki, F. Péron, Maison Petit, A. A. du Petit-Thouars, F. Prévost, J. Pucheran, J. R. C. Quoy, R. H. Schomburgk, Maison Verreaux, L. P. Vieillot, Voy. Astrolabe, Voy. Astrolabe & Zélée, Voy. Coquille, Voy. Géographe, Voy. Naturaliste, Voy. Urania, Voy. Vénus, K.Y. Yen

approx. nr. of bird skins 161,000, incl. c.30,000 mounts (6,755 species: c.75% of all bird species)

other bird items 8,000 skeletons, c.2,000 birds in spirits, 300+ tissue samples, 5,000 egg sets, many nests

approx. recent annual increase in skins below 100, from local birds skinned by own taxidermist and own expeditions (few at present)

bird skin collection specialised in worldwide, but especially Afrotropics, Madagascar, China, SE Asia, Indonesia, Australia, Pacific islands, (sub)antarctic islands, C & S America; c.2,620 types, many extinct and endangered birds; 8,500 skins from France

card or computer system present types, skeletons, and bird skins from France on computer

Pisa (MSNTP)

Info from: M. Zuffi, 19 Nov 2001

address Museo di Storia Naturale e del Territorio, Università di Pisa, Via Roma 79, I-56011 Calci (Pisa), Italy

telephone #-39-50-937092, **fax** #-39-50–937778, **e-mail** marcoz@museo.unipi.it

staff responsible for bird coll. Marco A. L. Zuffi (Curator of Zoology and Comparative Anatomy of non-mammal vertebrates)

total staff of bird dept See above

brief history Founded about 1750, now belongs to the University of Pisa

references to history, collections, or types Savi (1927–1929) (on Savi coll.), Secone & Zuffi (1996) (catalogue of nests and eggs)

important past bird staff Paolo Savi

important collections come from An anonymous person from Lucca (donated many local birds in early 1900s)

approx. nr. of bird skins 10,000 (incl c.9,000 mounts)

other bird items 275 (partial) skeletons, 50 in alcohol, 1,100 eggs, 800 nests, 450 anatomical preparations

approx. recent annual increase in skins 15–20

bird skin collection specialised in Italy, esp. Pisa area and Toscana region generally (e.g. the Savi coll., containing the types of several well-known European taxa, but Savi material is partly lost); also the Americas, C & S Africa, Middle East, SE Asia, Australia, with birds of virtually all families, incl. extinct birds like *Fregilupus varius* and *Pinguinus impennis*

card or computer system present 3,500 birds on card and computer

Prague/Praha (MNHP or NM Praha)

Info from: Pavel Janda, 21 Jan 2000

address Národní Muzeum, Zoologické oddelení, Václavské námestí 68, CZ-11579 Praha 1, Czech Republic

telephone #-42-2-2449 7224, **fax** #-42-2-2422 6488, **e-mail** milos.andera@nm.cz (Milos Andera, head of zool dept)

staff responsible for bird coll. Pavel Janda (coll. manager), Pavel Kameník (assistant)

total staff of bird dept See above

brief history Founded 1818, owned by the government

references to history, collections, or types Varga (1973), Stepanek (1975) (history)

important past bird staff Antonín Fric, Jan Hanzák, Jan Hora, Frantisek Pojer

important collections come from C. von Feldegg, J. V. Voboril, E. Holub, Duke L. von Habsburg, K. Knezourek, A. Horice, J. Musilek, J. von Seilern, K. Plachetka, B. K. Kinsky, J. Jirsik, F. Hromadka, F. Mocek, M. Vach, J. Urbanek, R. Prazny

approx. nr. of bird skins 22,000 skins

other bird items 120 skeletons, 900 sternums, 4,400 egg sets; head and bones of a Dodo *Raphus cucullatus*, adult & juvenile of *Pinguinus impennis*, pair of *Camptorhynchus labradorius*, etc

approx. recent annual increase in skins 10, from local birds and zoo specimens skinned by own taxidermist

bird skin collection specialised in Bohemia, Balkan, E Siberia, South & North America, South Africa, New Guinea; Trochilidae (10,000 skins)

card or computer system present most on card, part of the mounts on computer

Prerov (MOSPrerov)

info from: Frantisek Hanak, 8 Dec 1999

address Muzeum J. A. Komenského, Moravská ornitologická stanice, Horní námesti 1, 751 52 Prerov, Czech Republic

telephone #-420-641-219910

staff responsible for bird coll. Frantisek Hanák (head), Jiljí Sitko (helminthology of birds)

total staff of bird dept. 1 head, 2 coll. managers, 1 taxidermist, 1 librarian, 1 other

brief history Founded in 1970, owned by the government

references to history, collections, or types Hanak (1991), Sitko (1986, 1991, 1996); also *Zprávy MOS* 37 (1979): 9-35

important past bird staff Frantisek Hejl

important collections come from F. Hejl, L. Holub, Zdenek Kluz, O. Lipecky, J. Rehurek, V. Sajdl, V. Tichy, Jirí Toufar (eggs), Z. Verbis, E. S. Vráz

approx. nr. of bird skins 6,100 (393 species) skins remaining after flooding of coll. in Jul 1997

other bird items 1,700 sternums (110 species), 3,060 egg sets (12,665 eggs, of 181 species), 14,000 trematodes of birds

approx. recent annual increase in skins 100, from own expeditions, donations, and local birds skinned by own taxidermist

bird skin collection specialised in Moravia, Czech Republic generally; also, 463 exotic birds (330 species).

note The floods of July 1997 destroyed part of the original skin series and 50% of the books and journals.

card or computer system present All on card, part on computer

Reykjavik (IMNH /NHMR)

Info from: Æ. Petersen, 02 Aug 1996

address Icelandic Institute of Natural History (Náttúrufraedistafnun Islands, formerly Icelandic Museum of Natural History), P.O. Box 5320, IS-125 Reykjavik, Iceland (visitors address: Hlemmur 3)

telephone #-354-56-29822, **fax** #-354-56-20815, **e-mail** ni@nattfs.is, or: aevar@nattfs.is

staff responsible for bird coll. Dr Ævar Petersen

total staff of bird dept. 1 head, 1 taxidermist, c.1 other (various part-time helpers)

brief history Founded in 1889 by the Icelandic Natural History Society; to Iceland government from 1947

references to history, collections, or types Petersen (1984)

important past bird staff Finnur Gudmundsson

important collections come from —

approx. nr. of bird skins 14,000 (450 species)

other bird items 1,500 skeletons, 100 in alcohol, 2,600 egg sets, 650 nests

approx. recent annual increase in skins 200, from local birds skinned by own taxidermist, own expeditions, and donations

bird skin collection specialised in Iceland; Greenland, Faeroes

card or computer system present 90% of skins on card and computer (these almost all Icelandic birds, but not rechecked yet to coll.)

Rome/Roma (MZGZ)

(questionnaire not returned; some info from C. Violani, 14 Nov 1999 & N. Baccetti 6 Apr 2000)

address Museo Civico di Zoologia di Roma, Via Aldrovandi 18, I-00197 Roma, Italy

telephone and fax #-39-6-3216586, **e-mail**

staff responsible for bird coll. R. Carlini (head), B. Cignini

total staff of bird dept. 1 head, 2 taxidermists

brief history ?

references to history, collections, or types Arrigoni degli Oddi (1929), Foschi *et al.* (1995, 1996)

important past bird staff A. Carruccio

important collections come from E. Arrigoni degli Oddi (10,373 skins), Antinori, F. Chigi della Rovere, M. Blanc, G. von Burg, Collett, Dal Nero, Lepri, Loria, G. B. Dinesen, Farren, Gallardo, M. Härms, Melloni, A. Owston, D. Rossi, W. Schlüter, R. Baron Snouckaert van Schauburg, R. von Thanner, V. von Tschusi, Mus. Zagreb

approx. nr. of bird skins 15,000

other bird items ?

approx. recent annual increase in skins ?

bird skin collection specialised in Italy (esp. Veneto and Sardinia), Europe, Tunisia, Borneo, New Guinea

card or computer system present the Arrigoni coll. is catalogued on computer

note A small coll. of 306 mounted birds, largely from Lazio with some from the remainder of Italy and 4 from abroad is owned by Prince Ruspoli, in the Palazzo Ruspoli di Cervetari in Roma (*Avocetta* 25: 153).

Rotterdam (NMR)

Info from: Kees Moeliker, 16 Oct 1999

address Natuurmuseum Rotterdam, Westzeedijk 345 (Museumpark), 3015 AA Rotterdam/ POBox 23452, 3001 KL Rotterdam, Nederland.

telephone #-31-10-4364 222, **fax** #31-10-4364 399, **e-mail** moeliker@nmr.nl.

staff responsible for bird coll. Drs C. W. ('Kees') Moeliker (curator, also for other animals)

total staff of bird dept. C. W. Moeliker, Dr C. J. Heij (honorary curator), Dr E. J. O. Kompanje (honorary curator)

brief history Founded 1920; owned by a society, the Vereniging Natuurmuseum Rotterdam

references to history, collections, or types none

important past bird staff C. Eykman

important collections come from Coll. of the Rotterdam Zoological Garden, received in 1939, containing many important historical specimens from the Netherlands

approx. nr. of bird skins 2,200 (including 1,200 mounts) (c.350 species)

other bird items 5,000 skeletons & skulls (300 species), 300 birds in alcohol, 500 egg sets, 50 buffered tissue samples

approx. recent annual increase in skin/ skeleton coll. 250, from donations, exchanges, and local birds skinned by own taxidermist

bird skin collection specialised in Europe (especially the Netherlands), a few Indonesia; skeletons of Laridae

card or computer system present 50% on card, 10% on computer

Sarajevo

Info from: Svjetoslav Obratil & Denana Buturovic, 30 Dec 1999

address Zemaljski Muzej Bosne i Hercegovina Sarajevo (National Museum of Bosnia and Herzegovina), Zmaja od Bosne 3, BiH-71000 Sarajevo, Bosna i Hercegovina

telephone #-387-71-668025 **fax** #-387-71-668027

staff responsible for bird coll. Dr Svjetoslav Obratil (curator of birds), Dr Drazen Kotrosan (bird scientist), Zuza Borivoje (bird taxidermist), Dr Denana Buturovic (director of entire museum)

total staff of bird dept. See above

brief history Founded as Landesmuseum für Bosnien-Hercegowina in 1888, with Otmar Reiser as first director (to 1914). Now owned by the Sarajevo Canton of the Federation of Bosnia and Herzegovina

references to history, collections, or types Reiser (1891)

important past bird staff Otmar Reiser, C. Floericke, L. von Führer, K. Schilling von Canstatt, Dr Sijaric

important collections come from Reiser's coll. of c.9,500 Balkan skins

approx. nr. of bird skins 10,234 (incl. 1,255 mounts) (over 400 species)

other bird items 4,112 eggs (neglected since arrival in 1892), 90 nests

approx. recent annual increase in skins ?

bird skin collection specialised in Balkan countries and Greece; 696 exotic species

card or computer system present none, only inventory books

Sevenoaks (HZM)

Info from: Paul Bates, 02 Apr 1997

address The Harrison Zoological Museum, Bowerwood House, St Botolph's Road, Sevenoaks, Kent TN13 3AQ, England

telephone & fax #-44-1732-742446, **e-mail** hzm@btinternet.com

staff responsible for bird coll. Dr Paul Bates

total staff of bird dept. 1 part-time coll. manager (for entire coll., not for birds only)

brief history Founded in 1920 as the private coll. of James M. Harrison; now a private charitable trust

references to history, collections, or types none [but, e.g. Harrison (1953) was based on coll.]

important past bird staff James M. Harrison, Jeffery Harrison, David Harrison

important collections come from large private colls. of W. Payne and C. B. Ticehurst; also, skins of E. Flükiger, K. Kobayashi, P. Patev (Pateff), etc

approx. nr. of bird skins 19,500
other bird items a few skeletons, nothing else
approx. recent annual increase in skins 2, local birds
bird skin collection specialised in Palearctic; emphasis on ducks, waders, and passerines
card or computer system present all on card system and on computer

Seville/Sevilla (EBD)

Info from: J. Cabot Nieves, 08 Aug 1996
address Estacíon Biologica de Doñana, Consejo Superior de Investigaciones Científicas (CSIC), Aptdo 1056, E-41080 Sevilla, Spain (visitors address: Avda. Maria Luisa s/n. Pabellon del Perú, E-41013 Sevilla)
telephone #-34-95-4232340 (or -8, -9), **fax** #-34-95-4621125
staff responsible for bird coll. Dr José (Pepe) Cabot Nieves
total staff of bird dept. 1 head, 3 coll. managers, 2 taxidermists
brief history Founded in 1970 by Dr J. A. Valverde; now managed by the Consejo Superior de Investigaciones Científicas (CSIC)
references to history, collections, or types Cabot Nieves (1992)
important past bird staff J. A. Valverde
important collections come from Dr Castroviejo, Dr M. Delibes
approx. nr. of bird skins 22,000 (1,574 species)
other bird items 1,000 skeletons, 575 in alcohol, 1,344 egg sets
approx. recent annual increase in skins 1,000, from local birds skinned by own taxidermist and expeditions
bird skin collection specialised in Spain, Portugal, Morocco, Algeria, Western Sahara, Gabon, Equitorial Guinea, São Tomé, Príncipe, Philippines, Mexico, Nicaragua, Venezuela, Bolivia, Chile, Paraguay, Argentina
card or computer system present all skins in catalogue book, c.75% on computer

Sibiu (MBS)

Info from: Doru Banaduc, 10 Dec 2001
address Muzeul Brukenthal – Muzeul de Istorie Naturala, 1 Cetatii Street, RO-2400 Sibiu, Romania
telephone #-40-69-436868/ 09-2604338, **e-mail** banaduc@yahoo.com
staff responsible for bird coll. Dr Doru Banaduc (curator for all vertebrates)
total staff of bird dept. See above
brief history The natural history dept. of the museum was founded in 1849 by the Siebenbürgischen Verein für Naturwissenschaften; now belongs to the Ministerul culturii of Romania
references to history, collections, or types Popescu (1986)
important past bird staff E. A. Bielz, F. W. Stetter, D. Czekelius sr., K. Fuss, C. F. Jickel, W. Knöpfler, W. Hausmann, A. Müller, A. Neugeboren, E. Witting, A. von Spieß, C. Orendi, Alexius Buda, A. Kamner, D. Stanescu, H. Stein, C. Popescu, I. Wördinger
important collections come from F. W. Stetter, J. Gromer, P. Theil, Adam Buda, J. F. & F. Binder, C. Melisca, K. Neugeboren, A. Senoner, R. Klement
approx. nr. of bird skins 2,526 (of which c.2,000 mounted)
other bird items 594 skeletons & skulls, 1,575 eggs, 603 birds in alcohol and nests
approx. recent annual increase in skins strongly variable
bird skin collection specialised in mainly regional, but also includes birds from elsewhere in Romania and Europe, and 429 exotic birds
card or computer system present both partially only

Siena (MZAFS)

Info from: N. Baccetti, 5 Apr 2000
address Museo Zoologico dell'Accademia dei Fisiocritici, Piazza Sant'Agostino 4, I-53100 Siena, Italia
telephone #-39-0577-47002, **fax** #-39-0577-47002, **e-mail** cancelli@unisi.it
staff responsible for bird coll. Prof. Baccio Baccetti (supervisor of Zoological Museum), Fabrizio Cancelli (coll. manager and taxidermist), Dr Nicola Baccetti, Dr Francesco Pezzo (volunteer associates)
total staff of bird dept. 1 coll. manager and taxidermist (for all animals)
brief history Founded 1759 by G. Baldassarri; all pre-1798 specimens destroyed by earthquake. Main period of activity 1840–1910. Oldest published catalogue: Baldacconi (1845). The colls. were largely neglected during 1935–1970, but the museum re-opened

in 1972, when also old colls. of the University of Siena (dating from 1900–1930) were added and a modern taxidermy laboratory was founded

references to history, collections, or types Ricci (1972), Baccetti (1885), Baccetti (1996), Cancelli *et al.* (in prep.)

important past bird staff Massimiliano Ricca, Apelle Dei, Sigismondo Brogi

important collections come from A. Dei, Baron B. Ricasoli, C. Passerini, with 327, 507, resp. 206 specimens still existing; a few duplicates from Savi (*ante* 1840).

approx. nr. of bird skins 2,556 (810 species); mainly mounts

other bird items a few skeletons

approx. recent annual increase in skins 50, from local birds skinned by own taxidermist and donations

bird skin collection specialised in Central Italy (1,099 birds from Tuscany). Coll. includes skins of several endangered birds (e.g. *Numenius borealis*, *N. tenuirostris*, *Strigops habroptilus* etc.)

card or computer system present All on computer; several old partial catalogues

Sofia (NMNHS/NZMS)

Info from: Z. Boev, 04 Apr 1997, updated 13 Nov 1999 and 10 Nov 2001

address National Museum of Natural History, Bulgarian Academy of Sciences, Blv. Tsar Osvoboditel 1, BG-1000 Sofia, Bulgaria

telephone #-359-2-9879326, **fax** #-359-2-9882897, **e-mail** nmnhzb@bgcict.acad.bg or boevzaro@yahoo.co.uk

staff responsible for bird coll. Prof. Dr Zlatozar Boev (head of fossil and recent bird dept.)

total staff of bird dept. 1 head/ coll. manager, 1 secretary; also (for entire museum) 1 taxidermist, 1 librarian

brief history Founded in 1889 by King Ferdinand I Sachsen Coburg-Gotha of Bulgaria, grew rapidly but part of coll. lost in fire in March 1944; now belongs to the Bulgarian Academy of Sciences

references to history, collections, or types Anon. (1907), Boev (1990, 1991, 1994, 1997)

important past bird staff Ferdinand I of Bulgaria, P. Leverkühn, Boris III of Bulgaria, K. Andersen, H. Gretzer, P. Patev, N. Boev, S. Donchev

important collections come from Amedé Alleon, Stuart Baker, H. von Boetticher, I. Buresch, E. Holub, Julius, E. Werner (700 birds, from 19 countries)

approx. nr. of bird skins 15,500 (incl. 4,155 mounts) (1,200 species)

other bird items 13,000 (sub)fossil remains (23% of the fossil bird species known), 2,000 skeletons, 50 in alcohol, 260 egg sets, 12 nests

approx. recent annual increase in skins 20, from local birds skinned by own taxidermist; also, many fossils added

bird skin collection specialised in Bulgaria, European Turkey (Alleon coll.), N Germany (Werner coll.), India; 11 *Numenius tenuirostris*

card or computer system present all skins on card system, none on computer

Stavanger

Info from: K. Skipnes, 31 Jan 2000

address Stavanger Museum, Zoologisk Avdeling, Musé gt. 16, N-4010 Stavanger, Norway

telephone #-47-5184 2711, **fax** #-47-5184 2701, **e-mail** kolbjorn.skipnes@stavanger.museum.no **website** www.stavanger.museum.no

staff responsible for bird coll. Kolbjørn Skipnes (curator), Olav Runde (head)

total staff of bird dept. 1 head, 1 curator, 1 taxidermist, 1 secretary, 1 assistant (all for entire zoology coll.)

brief history Founded 1877

references to history, collections, or types Skipnes (1989), Runde (1991)

important past bird staff H. Tho. L. Schaanning, A. Berhhoft-Osa, Holger Holgersen

important collections come from J. Koren, Voy. Maud

approx. nr. of bird skins 4,200 (944 species)

other bird items ?

approx. recent annual increase in skins ?

bird skin collection specialised in Rogaland area (W Norway), Norway generally, Novaya Zemlya, Arctic Siberia

card or computer system present all on card, part on computer

Stockholm (NRM)

Info form: P. Ericson, 31 Oct 1995, updated 13 Nov 1999

address Naturhistoriska Riksmuseet, Research dept., Sektionen för Vertebratzoologi, Box 50007, S-10405 Stockholm, Sweden (visitors address: Frescativägen 44)

telephone #-46-8-666-4000, **fax** #-46-8-666-4212, **e-mail** p.ericson@nrm.se

staff responsible for bird coll. Dr Per Ericson (head), Göran Frisk (coll. manager), Dr Carl Edelstam (retired, voluntary associate)

total staff of bird dept. 1 head, 1 coll. manager, 3 taxidermists, 1 other

brief history Founded in 1739 as cabinet of the Royal Academy of Sciences (under presidency of C. von Linné), but a real increase in the coll. size occurred only when a new building was erected 1819–1820, when also the private coll. of G. von Paykull arrived. A few hundreds of specimens from the last decades of the eighteenth century are still present. Now belongs to the Swedish government

references to history, collections, or types Lönnberg (1926), Gyldenstolpe (1926)

important past bird staff Anders Sparrman, Sven Nilsson, Carl J. Sundevall, Fredrik A. Smitt, Friedrich W. Meves, Einar Lönnberg, Nils Gyldenstolpe, Carl Edelstam

important collections come from Adelborg, J. G. Anderson, K. Bäckstrom, O. Bamberg, C. Bangert, S. Bergman, Dr Bovallius, Von Carlsson, Eisenhofer, G. W. Freyreiß, S. H. Granvik, J. W. Grill, J. Hedenborg, S. Hedin, G. von Hofsten, P. A. Holst, G. Kolthoff, K. E. Laman, S. Lovén, E. P. Mjöberg, Nathorst, R. Nicolin, Nordenskiöld, A. M. Ollala, H. Sandeberg, B. Y. Sjöstedt, K. G. Söderbom, L. Söderstrom, P. Spatz, T. F. Tullberg, J. F. Victorin, Voy. Eugenie, Voy. Vega, J. A. Wahlberg, General Westin, G. de Wylder, O. Graf von Zedlitz (private coll. of c.7,500 skins, stored separately)

approx. nr. of bird skins 105,000 (c.6–7,000 species)

other bird items 13,000 skeletons, 1,100 in alcohol, 27,000 egg sets

approx. recent annual increase in skins 100 skins & 900 skeletons/alcohol specimens, from expeditions and local birds skinned by own taxidermist

bird skin collection specialised in Sweden, Fenno-Scandia, Arctic (Greenland, Iceland, Svalbard, North European Russia), Iran, C & E Asia (Kamchatka, Kuril Is., Sakhalin, China, Mongolia, Tien Shan), Thailand, Malaya, N, NE, C & S Africa, New Guinea, Nicaragua, Galapagos Is., South America, Middle East

card or computer system present all skins on card, 95% of skins, skeletons, and eggs on computer

St Petersburg/Sankt-Peterburg (ZISP)

Info from: V. Loskot, 25 Aug 1995

address Zoologicheskii Institut, Rossiiskoi Akademii Nauk (Russian Academy of Sciences), dept of Ornithology, Universitetskaya nab. 1, 199034 Sankt-Peterburg, Russia

telephone #-7-812-2180011, **fax** #-7-812-114-04444, **e-mail** SOA@ZISP.SPB.SU

staff responsible for bird coll. Dr Vladimir M. Loskot (head), Dr L.V. Firsova, A.V. Panteleev, Dr A.M. Sokolov, Dr E.P Sokolov

total staff of bird dept. 1 head, 1 coll. manager, 3+ others

brief history Founded in *c.*1714 as private 'Kunstkamer' of Peter the Great, but intense skin collectioning occurred only from c.1820 onwards; from 1832, the coll. became part of the Zoological Museum of the Imperial Acadademy of Sciences (now Russian Academy of Sciences)

references to history, collections, or types Neufeldt (1978), Scarlato (1982), Sokolov & Il'yashenko (1987)

important past bird staff J. F. Brandt, T. (= F. D.) Pleske, N. M. Przhevalskii, V. L. Bianchi, P. P. Sushkin, B. K. Stegmann, E. V. Kozlova, A. Ya. Tugarinov, L. A. Portenko, A. I. Ivanov, K. A. Yudin, I. A. Neufeldt

important collections come from K. M. Baer, M. M. Berezowskii, T. T. Brandt, Bykov, V. S. Elpatev, E. A. Eversmann, J. P. Falk, L. von Führer, S. G. Gmelin, G. E. & M. E. Grum-Grzhimailo, J. A. Güldenstädt, C. L. Hablizl, F. H. von Kittlitz (754 specimens), P. K. Kozlov, K. Krebs, G. H. Baron von Langsdorff, I. Lepechin, R. K. Maak, M. A. Menzbier, C. Merck, A. von Middendorff, P. S. Pallas, M. V. Pevtsov, G. N. Potanin, F. L. Potapov, G. Radde, J. Riedel, V. I. Roborovskii, L. von Schrenck, N. A. Severtzov, L. M. Shulpin, G. W. Steller (1 certain specimen only), P. P.

Sushkin, Voy. Nadezhda, Voy. Senyavin, I. G. Voznesenski, N. A. Zarudny

approx. nr. of bird skins 170,000 (4,240 species)

other bird items 2,700 skeletons, 7,500 in alcohol, c.20,000 eggs and nests

approx. recent annual increase in skins 150, from own expeditions

bird skin collection specialised in former Soviet-Union, Mongolia, China, Poland, Brazil, North Pacific

card or computer system present all skins on card, alcohol and skeletons on computer.

St Petersburg/Sankt-Peterburg (ZM SPBU)

Info from: Irina Savinich, 28 Jan 2000

address Zoological Museum, Dept of Vertebrate Zoology, Faculty of Biology and Soil Sciences, St Petersburg State University, Universitetskaya nab. 7/9, 199034 Sankt-Peterburg, Russia

telephone #-7-812-324 0885, **fax** #-7-812-328 9689, **e-mail** irene@isav.usr.pu.ru

staff responsible for bird coll. Dr Irina Savinich (curator, senior lecturer)

total staff of bird dept. 1 curator

brief history Founded 1819, but real increase not until arrival of S. Kutorga in 1833 and especially K. Kessler in 1862. Now part of the University

references to history, collections, or types Shimkevich & Vagner (1899), Raykov (1953), Malchevsky & Polyansky (1969) (all on history)

important past bird staff V. Andreevsky, Th. Pleske, W. Shimkevich, M. Bogdanov, A. Nikolsky, E. Buchner, V. Bianki, K. Derjugin, P. Kashkarov, L. Shulpin, A. Malchevsky

important collections come from Prince Alexis of Russia, Bilkevich, Meves (eggs)

approx. nr. of bird skins 4,500 (1,100 species), incl. mounts

other bird items 150 skeletons, 150 spirit specimens, 140 frozen tissue samples, 800 egg sets, 100 nests, and 1,160 recordings of birds sounds

approx. recent annual increase in skins 40, from own expeditions, donations, and local birds skinned by own taxidermist

bird skin collection specialised in Russia, Central Asia

card or computer system present part on card, with another part of the card system burnt in 1995; computerisation just started

Strasbourg (MZS)

Info from: Élisabeth Lang, 6 Dec 2001

address Musée zoologique de l'Université Louis Pasteur et de la Ville de Strasbourg, 29 Boulevard de la Victoire, F-67000 Strasbourg, France

telephone #-33-3-90-240489 or -90, **fax** #-33-3-90-240558, **e-mail** elang@cus-strasbourg.net, **website** www.mairie-strasbourg.fr

staff responsible for bird coll. Mme Élisabeth Lang (head conservator), Marie-Dominique Wandhammer (birds)

total staff of bird dept. 2 (see above)

brief history Based on a coll. of c.900 birds of Johann Hermann, started in 1760 (but few of these remain), later bought by the Ville de Strasbourg and serving as a base for a museum; still belongs to the city of Strasbourg but jointly curated by the university and city

references to history, collections, or types Koenig (1993, 1994) (catalogues of Madagascar birds and Anseriformes)

important past bird staff P. Koenig, O. Langrand

important collections come from Von Berg, Berger, G. A. Frank, Lantz, Mus. Saint-Denis (Réunion), Pougnet, Pouillet, G. Schneider, Sicard, Ursch, Wehrung

approx. nr. of bird skins 18,000 (incl. mounts)

other bird items 50 (partial) skeletons, 17 in liquid, 2,000 eggs sets, 300 nests

approx. recent annual increase in skins 20

bird skin collection specialised in worldwide (e.g. over 300 from Madagascar), all families (e.g. 720 ducks of 120 species); includes extinct birds like *Camptorhynchus labradorius* and *Rhodonessa caryophyllacea*

card or computer system present all on card

Stuttgart (SMNS)

Info from: M. Grabert, 06 Nov 1996; updated Friederike Woog, 11 Jan 2002

address Staatliches Museum für Naturkunde, Rosenstein 1, D-70191 Stuttgart, Germany (visitors address: Museum Schloß Rosenstein)

telephone tel. #-49-711-8936-253, **fax** #-49-711-8936-200, **e-mail** woog.smns@naturkundemuseum-bw.de

staff responsible for collection Dr Claus König (director), Dr Friederike Woog (curator of birds), Severine Mattes (taxidermist), Holger Haag (scientific assistant)

total staff of bird dept. 1 curator, 1 coll. manager, 1 taxidermist, 5 volunteers

brief history Founded in 1791 by Herzog C.-E. von Württemberg; now belongs to the government of Baden-Württemberg

references to history, collections, or types Van den Elzen & König (1983), König (1991)

important past bird staff Ernst Schüz, M. Grabert

important collections come from T. Andersen, C. von Barth, A. Boucard, Chevalier, Coll. Duoc, Duve, Elliot, A. Fischer (6,000 skins), G. Frank, K. Fritsche, W. & P. Gatter, H. Grün, H. Gude, Th. von Heuglin, H. von Hochstetter, G. Hoy, A. Kappler, C. F. H. Baron von Ludwig, H. Möschler, F. von Müller, G. Nikolaus, W. Salzmann, F. Sarg, W. Schlüter, F. K. I. Streich, Herzog Paul von Württemberg

approx. nr. of bird skins 70,000, incl. 15,000 mounts (5,500 species)

other bird items 6,000 (partial) skeletons, 10,000 egg sets, 1,000 nests, 8,000 spread wings

approx. recent annual increase in skins 200, from expeditions, local birds skinned by own taxidermist, and buying of colls.

bird skin collection specialised in Palearctic, South America (e.g. Surinam), Liberia, Tanzania, and many other parts of the world

card or computer system present most skins on card, c.50% on computer

Tartu

Info from: Rainer Ilisson, 13 January 2000

address Zooloogia muuseum/ Museum of Zoology, Tartu Ülikool/Tartu University, Vanemuise Str. 46, EE-51014 Tartu, Estonia

telephone #-372-7-375833, **e-mail** jux@ut.ee, jluig@ut.ee, webpage http://www.ut.ee/~BGZM

staff responsible for bird coll. Rainer Ilisson (birds), Jaan Luig (chief curator all animals)

total staff of bird dept. 1 (see above)

brief history Founded 1802, but the coll. was mainly formed in 1905–1912 (when birds from various parts of Russia arrived) and in 1920s–1930s and 1950s (largely birds from Estonia). Owned by University of Tartu

references to history, collections, or types Ilisson (1992) (skins), Ong (1996) (eggs)

important past bird staff V. Russow, M. Härms, J. Piiper, J. Lepiksaar, E. Kumari

important collections come from A. Graf Keyserling, O. von Koch (eggs & nests), both private, and the coll. of the Institute of Zoology and Botany of the Academy of Sciences of Estonia (Dr Vilju Lilleleht)

approx. nr. of bird skins 8,500 (over 800 species)

other bird items 2,000 skeletons (c.150 species), c.3,000 egg sets (357 species), 100 nests

approx. recent annual increase in skins a few

bird skin collection specialised in Estonia; former Soviet Union generally

card or computer system present skins and eggs on card, but not skeletal material

Terrasini

Info from: N. Vitale, 25 Aug 1997

address Museo di Storia Naturale di Terrasini, Via Cala Rossa 14, 90049 Terrasini (Palermo), Sicilia, Italy

telephone #-39-091-868 2497, **fax** #-39-091-868 2420

staff responsible for bird coll. Sig. Nino Vitale (curator), Bruno Massa (pres. Scient. Com.), Vittorio E. Orlando, Marcello Arnone (honorary curators)

total staff of bird dept. 1 head, 1 taxidermist, 1 librarian

brief history Founded c.1928–1930 by C. Orlando; now, the buildings owned by the Municipality of Terrasini, the colls. by the Sicily Region

references to history, collections, or types Arnone & Orlando (1990), Massa (1977), Orlando (1978, 1990a,b, 1991, 1995a,b)

important past bird staff C. Orlando

important collections come from Sig. Ajola, M. Arnone, M. Jannizzotto, C. & V. E. Orlando, A. Trischitta, F. Venezia, A. Vitale

approx. nr. of bird skins 8,000 (600 species)

other bird items 25 skeletons, 15 in alcohol, 150 egg sets, 316 nests, 4,000 various

approx. recent annual increase in skins ?, from local birds skinned by own taxidermist

bird skin collection specialised in Sardinia, Sicily, mainland Italy, Europe. Together 5,781 birds from coll. C. Orlando, 1,895 coll. A.

Trischitta, 284 coll. M. Jannizzotto, and 120 coll. A. Vitale; types of 14 taxa

card or computer system present all skins on card and computer

Tervuren (KMMA / MRAC)

Info from: M. Louette, 25 Jan 1995

address Koninklijk Museum voor Midden-Afrika / Musée Royal de l'Afrique Centrale, Steenweg op Leuven 13, B-3080 Tervuren, Belgium

telephone #-32-2-7695211, **fax** #-32-2-7670242, **e-mail** louette@africamuseum.be

staff responsible for bird coll. Dr Michel Louette (head), M. Herremans, W. Plompen M.Sc., P. Herroelen (volunteer)

total staff of bird dept. 1 head, 0.2 coll. manager, 0.25 secretary

brief history Founded in 1897 to house colls. made in Central African colonies. Belongs to the Belgian government

references to history, collections, or types Louette (1980)

important past bird staff H. Schouteden, J. P. Chapin, A. Prigogine, A. de Roo

important collections come from Bonnevie, Hutsebaut, F. J. Jackson, C. M. de la Kethulle, Captain Pauwels, A. Pillette, Voy. C. Christy, Voy. Rosenberg (G. L. Bates, W. J. Ansorge, Usscher), A. F. G. Weyns, G. F. de Witte

approx. nr. of bird skins 150,000 (over 8,000 species)

other bird items 500 skeletons, 15,000 in alcohol, 1,500 egg sets, 400 nests

approx. recent annual increase in skins 400, from expeditions and donations

bird skin collection specialised in Central Africa; all Afrotropical families

card or computer system present part of skins on card, soon on computer

Torino see Turin

Toulouse (MHNT)

Info from: Pierre Dalous, 20 Dec 2001

address Museum d'Histoire Naturelle de Toulouse, 35 Allées Jules Guesde, F-31000 Toulouse, France

telephone #-33-5-61-479225, **fax** #-33-5-61–554275, **e-mail** pierre.dalous@mairie-toulouse.fr

staff responsible for bird coll. Dr Pierre Dalous

total staff of bird dept. 1 (for all vertebrates)

brief history Founded in about 1900; owned by city

references to history, collections, or types -

important past bird staff -

important collections come from V. Besaucèle, R. Bourret, G. Cossaune, M. Gourdon, Hammonville, A. Lacroix, Reboussin

approx. nr. of bird skins 8,900 (incl. 7,500 mounts)

other bird items c.2,000 skeletons & skulls, 5,300 eggs

approx. recent annual increase in skins 20

bird skin collection specialised in Europe (especially France), but also a fair number of exotic species

card or computer system present All on computer, except skeletons/ skulls

Tring (BMNH or NHM)

Info from : R. Prŷs-Jones, 18 Nov 1994, F. Steinheimer 22 Nov 2001

address The Natural History Museum, Bird Group, Akeman Street, Tring (Herts) HP23 6AP, U.K.

telephone #-44-207-942-6158, **fax** # -44-207-942-6150, **e-mail** (preferably) bird-enquiries@nhm.ac.uk or (direct) R.Prys-Jones@nhm.ac.uk, m.adams@nhm.ac.uk, f.steinheimer@nhm.ac.uk, m.walters@nhm.ac.uk, jhc@nhm.ac.uk.,

staff responsible for bird coll. Dr Robert Prys-Jones (head), Mark Adams (skins & loans), Michael Walters (eggs & nests), Jo Cooper (alcohol, skeletons), Frank Steinheimer (associate)

total staff of bird dept. 1 head, 4 curators

brief history Founded in 1753 as private coll. of Hans Sloane; now belongs to the government

references to history, collections, or types Sharpe (1874–1898, 1885, 1906), Warren *et al.* (1966–1973), Blandamer & Burton (1979), Stearn (1981), Knox & Walters (1992, 1994), Steinheimer (in press b)

important past bird staff G. Shaw, W. E. Leach, J. E. Gray, G. R. Gray, P. L. Sclater, R. Bowdler Sharpe, W. R. Ogilvie-Grant, P. R. Lowe, N. Kinnear, D. Snow, B. P. Hall, D. Goodwin, C. J. O. Harrison, I. C. J. Galbraith, P. R. Colston

important collections come from A. L. Adams, J. Aitchison, B. Alexander, J. Anderson, F. B.

Armstrong, D. A. Bannerman, G. L. Bates, R. C. Beavan, J. Biddulph, C. T. Bingham, W. Blanford, W. Blewitt, W. E. Brooks, G. Brown, F. Brüggemann, A. Buchanan, W. Buller, A. L. Butler, E. A. Butler, G. Caley, D. Carruthers, R. E. Cheesman, W. N. Chill, A. F. Christison, Miss Cockburn, J. Cockerell, Capt. P. Conrad, J. Cook, W. D. Cowan, C. & S. Coxen, J. N. Cripps, P. Crowley, H. Cuming, J. W. N. Cumming, C. R. Darwin, C. Davison, W. R. Davison, J. Delacour, P. M. Diard, F. Dörries, H. Durnford, Emin Pasha, A. H. Everett, T. C. Eyton, H. W. Feilden, H. O. Forbes, A. D. Forbes-Watson, D. Forsyth, L. Fraser, E. Gerrard, J. Gilbert, F. D. Godman, H. H. Godwin-Austen, A. Goldie, W. Goodfellow, P. Gosse, J. Gould, C. H. B. Grant, J. H. Gurney, E. Hargitt, H. H. Harington, E. Hartert, G. Henderson, H. W. Henshaw, B. H. Hodgson, P. A. Holst, T. Horsfield, A. O. Hume, India Mus., C. Ingram, F. J. Jackson, H. B. James, T. C. Jerdon, H. H. Johnston, E. G. Johnstone, F. C. R. Jourdain (eggs), H. J. Kelsall, J. Kirk, C. Boden Kloss, C. L. Landbeck, J. D. D. La Touche, E. & L. Layard, Linnean Society of London, J. J. Lister, C. Livingstone, W. L. Lloyd, G. Loddiges, W. P. Lowe, F. Ludlow, H. Lynes, J. MacGillivray, L. Mandelli, C. H. T. Marshall, J. McClelland, E. McConnell, R. Meinertzhagen, A. B. Meyer, G. Montagu, H. Moseley, J. Murray, E. Newton, E. W. Oates, A. Owston, Capt. Pemberton, H. Philby, S. Pinwill, J. Polatzek, H. Pryer, T. S. Raffles, S. G. Reid, W. B. Richardson, C. B. Rickett, Comte de Riocour, G. Rippon, H. C. Robinson, A. W. Roepstorff, W. F. H. Rosenberg, E. Rüppell, O. B. St John, O. Salvin, H. Saunders, R. H. Schomburgk, W. E. D. Scott, J. Scully, H. Seebohm, W. Serle, R. Shaw, F. Shaw Mayer, G. E. Shelley, G. Sherriff, H. H. Slater, A. Smith, H. Smith, L. Sowerby, W. Stalker, J. K. Stanford, S. Stevens, F. Stoliczka, C. Sturt, F. W. Styan, R. Strachey, C. & R. Swinhoe, W. H. Sykes, Tangier-Smith coll., W. R. Thompson, C. B. Ticehurst, S. Tickell, H. B. Tristram (eggs), Marquis of Tweeddale, J. Vincent, Voy. Alert, Voy. Blossom, Voy. Challenger, Voy. Erebus & Terror, Voy. Herald, Voy. Rattlesnake, Voy. Sulphur, A. R. Wallace, H. Walton, A. E. Ward, R. G. Wardlaw-Ramsay, J. Waterstradt, E. Weiske, H. Whistler, J. I. S. Whitaker, C. H. T. Whitehead, J. Whitehead, A. Whyte, E. Wilson, A. W. S. Wingate, H. F. Witherby, A. F. R. Wollaston, C. M. Woodford, C. K. Worthen, J. W. Yerbury, Zoological Society of London (L. Fraser, J. Gilbert, J. Gould, T. Horsfield, Raffles, N. Vigors, Voy. Beagle, G. R. Waterhouse), and many others

approx. nr. of bird skins 750,000 (8,492 species), excluding 6,000 mounts

other bird items 15,187 (partial) skeletons (2,600 species), 17,135 in spirit (3,300 species), 4-500,000 egg sets, 2,000 nests

approx. recent annual increase in skins 200, from local birds skinned by staff and donations

bird skin collection specialised in world-wide, all families

card or computer system present most egg sets on card, 33,000 skins and 24,000 egg sets on computer (e.g. skins of all extinct and endangered birds, most types, all Mexican and Spanish birds, and most Australian birds and Nectariniidae); types on museum web page

Tromsø (TSZV)

Info from: Robert Barrett, 26 Nov 2001

address Universitets Museet i Tromsø, Zoology Dept., Lars Thøringsvei 10, NO-9037 Tromsø, Norway

telephone #-47-77-645013/5010, **fax** #-47-77-645520, **e-mail** zoo@imv.uit.no, robb@imv.uit.no

staff responsible for bird coll. Dr Robert Barrett (for all zoology)

total staff of bird dept. 1 (see above)

brief history Founded 1872; part of Tromsø University

references to history, collections, or types -

important past bird staff W. Vader

important collections come from —

approx. nr. of bird skins 4,100

other bird items 512 (partial) skeletons, 890 egg sets

approx. recent annual increase in skins 20–200

bird skin collection specialised in Northern Norway, Spitsbergen, Arctic regions generally

card or computer system present All bird items on card and computer

Trondheim

Info from: O. Hogstad, 09 Apr 1997

address Museum of Natural History & Archaeology, Institute of Natural Histoy, dept. of Zoology, Norw. Univ. of Science and

Technology NTNU, N-7004 Trondheim, Norway (visitors: Vitenskapsmuseet, Erling Skakesgt. 47)
telephone #-47-7-3592207, **fax** #-47-7-3592295, **e-mail** olav.hogstad@vm.ntnu.no
staff responsible for bird coll. Dr Olav Hogstad (head zoology dept)
total staff of bird dept. 1 head, 1 taxidermist
brief history Founded in 1760 by J. E. Gunnerus and Det Kongelige Norske Videnskabens Selskab; now part of NTN University
references to history, collections, or types —
important past bird staff Y. Hagen, S. Haftorn
important collections come from —
approx. nr. of bird skins 3,200 (450 species)
other bird items a few skeletons and birds in alcohol, 400 eggs, 50 nests
approx. recent annual increase in skins 150, from local birds skinned by own taxidermist
bird skin collection specialised in c.3,000 skins from Norway (mainly central), 200 exotic
card or computer system present all skins on card and computer

Turin/Torino (MRSN)

Info from: C. Pulcher, 20 Nov 1996, some add. Dario Zuccon, 16 Oct 2002
address Museo Regionale di Scienze Naturali, Via Giolitti 36, I-10123 Torino, Italy
telephone #-39-011-432-3001, **fax** #-39-011-432-3331
staff responsible for bird coll. Dr Elena Gavetti (head of entire zoology section), Claudio Pulcher (part-time contractor for birds)
total staff of bird dept. 1 head (also for other sections), 1 temporary coll. manager, 1 temporary taxidermist
brief history Founded in c.1815, when Bonelli started the bird section of the Museum of Zoology of Torino University; now, the museum building is owned and the coll. managed by the government of the Regione Piemonte, but part of the bird coll. is owned by Torino University.
references to history, collections, or types Salvadori (1914), Tortonese (1957), Passerin d'Entrèves *et al.* (1986), Elter (1986), Violani *et al.* (1997)
important past bird staff F. A. Bonelli, G. Gené, F. De Filippi, A. T. Salvadori
important collections come from L. M. D'Albertis (c.380 birds), O. Antinori (c.1,000 birds), O. Beccari (c.350 birds), A. Borelli (1,000+ birds), A. A. Bruijn, Bullock coll./ Mus. Leverianum (see Vienna/Wien), G. Doria, L. Fea, E. Festa (4,100+ birds), E. H. Giglioli, L. Loria, Marquis of La Marmora, E. Modigliani, V. Ragazzi (c.700 birds), Count Solaroli, Voy. Magenta (F. de Filippi & E. H. Giglioli; c.1,150 birds), duplicates from the colls. of Gould, Rüppell, Savi, Swinhoe, Temminck, and others
approx. nr. of bird skins 21,000 (3,000 species)
other bird items over 100 skeletons and eggs
approx. recent annual increase in skins 0
bird skin collection specialised in Italy, Wallacea & West New Guinea (c.1,000 skins), Libya to Ethiopia (over 4,000 skins), South America (c.4,000 skins), Middle East (e.g. Iran), Himalayas, Burma, South Pacific; c.300 type specimens
card or computer system present a modernised version of the catalogue of Elter (1986) is on computer

Uppsala (ZMUU)

Info from: M. Eriksson, Mar 1998
address Evolutionsmuseet, Zoologi-sektionen, Uppsala Universitet, Norbyvägen 16, S-75236 Uppsala (visitors: Villavägen 9), Sverige
telephone #-46-4712668, **fax** #-46-4712794, **e-mail** mats.eriksson@ evolmuseum.uu.se
staff responsible for bird coll. Dr Mats Eriksson
total staff of bird dept. 5 (for entire zoology dept.)
brief history ?
references to history, collections, or types Wallin & Wallin (1994) (history), Wallin (1996, 1997) (types)
important past bird staff Sven Hörstadius
important collections come from A. W. Eriksson, L. A. Jägerskiöld, G. Kolthoff, A. Kovacs, T. Kumlien, M. Lagerström, W. Lilljeborg, C. von Linné, Melbourne Mus., D. Melin, B. Mörner, B. Pettersson, C. P. Thunberg, J. A. Wahlberg, General Westin, A. E. & J. G. Williams
approx. nr. of bird skins 6,900
other bird items ?
approx. recent annual increase in skins ?
bird skin collection specialised in Sweden (c.3,100, mainly Uppland, Skåne, Öland), Brazil (378), Svalbard (342), Greenland &

Faeroes (c.140 each), South Africa (188), Australia (183), Norway (c.110), Russia (104), USA (95), New Guinea (77)
card or computer system present all skins on computer

Venice/Venezia (MCSNV)

Info from: M. Bon, 17 Jul 1996
address Museo Civico di Storia Naturale di Venezia, S. Croce 1730, Fontegna dei Turchi, I-30135 Venezia, Italy
telephone #-39-041-524-0885, **fax** #-39-041-524-2592
staff responsible for bird coll. Dr Mauro Bon (head), Dr Giuseppe Cherubini , Massimo Semenzato (both volunteer associates)
total staff of bird dept. 1 head
brief history Founded in 1923 by the Municipality of Venezia (Venice), but includes older colls.; still owned by Municipality of Venezia
references to history, collections, or types Rallo (1988), Bon *et al.* (1993)
important past bird staff —
important collections come from G. Bisacco Palazzi, Conte A. P. Ninni
approx. nr. of bird skins 2,500 (400 species)
other bird items some skeletons, alcohol specimens, and egg sets
approx. recent annual increase in skins a few
bird skin collection specialised in north-east Italy, North Africa
card or computer system present part of skin coll. on card

Verona (MSNVR)

Info from: Roberta Salmasa, 22 Dec 1999
address Museo Civico di Storia Naturale, Lungadige Porta Vittoria 9, I-37129 Verona, Italia.
telephone #-39-(0)45-8079400, **fax** #-39-(0)45-8035639, **e-mail** leonardo_latella@comune.verona.it, roberta_salmaso@comune.verona.it.
staff responsible for bird coll. Dr Leonardo Latella (curator), Roberta Salmaso (technician) (both of entire zoology dept)
total staff of bird dept. see above
brief history Founded c.1906, oldest birds from c.1850 (no birds remaining from earlier Verona museums which latter date back to 1571); owned by the Commune (Municipality) di Verona
references to history, collections, or types Dal Fiume (1907)
important past bird staff V. Dal Nero, S. Rufo
important collections come from De Betta, Perini, Carraro, Cipolla, Dal Fiume, Zangheri's Museum
approx. nr. of bird skins 5,000 (600 species)
other bird items a few eggs and nests, 400 sternums
approx. recent annual increase in skins 1–2, local birds
bird skin collection specialised in north-east and central Italy, Eritrea (c.500 birds); includes 1 type: *Cryptolopha erytreae*
card or computer system present A large part on card and computer, but neither complete

Vienna see Wien

Warsaw/Warszawa (MZPW for coll., MIZ PAN for Institute)

Info from: Tomasz Huflejt, 22 Dec 1999
address Museum and Institute of Zoology, P. A. N. (Polish Academy of Sciences), Ul. Wilcza 64, PL-00 679 Warszawa, Poland
telephone #-48-629-3221 , **fax** #-48-629-6302 , **e-mail** thuflejt@robal.miiz.waw.pl
staff responsible for bird collection Tomasz Huflejt (entomologist, head of collection division)
total staff of bird dept. No ornithologists; entire staff of coll. division: 1 head and 3 assistants
brief history A combination of the cabinet of F. P. Jarocki (from 1819) and the private coll. of Constantin & Xaver Graf von Branicki (founded 1887), which latter came to government in 1919 (with Domaniewski as first director of the combination); now belongs to the Polish Acad. of Sciences
references to history, collections, or types Kazubski (1996) (history), Sztolcman & Domaniewski (1927) (type list)
important past bird staff L. Taczanowski, B. Dybowski, J. Sztolcman (Stolzmann), K. Jelski, J. Kalinowski, M. Jankowski, T. Chrostowski, J. Domaniewski, A. Dunajewski, S. Zielinski
approx. nr. of bird skins 40,000 (incl. c.5,000 mounts) (3,000 species)

other bird items many eggs sets; a few skeletons, birds in alcohol, nests, etc.; 380 types

approx. recent annual increase in skins About none in the last 30 year

bird skin collection specialised in Poland, Belarus, Ukraine, European Russia (esp. Caucasus area), Turkey, Uzbekistan, East Asia, China, Mongolia, Korea, Vietnam, South America (esp. Peru)

card or computer system present All as a list on paper and computer, but nomenclatorially partly outdated and with many misspellings

Wien (NMW)

Info from: Ernst Bauernfeind, 19 Jan 1995, updated 10 Nov 2001

address Naturhistorisches Museum, 1. Zoologische Abteilung – Vogelsammlung, Burgring 7, A-1014 Wien, Austria/ Österreich

telephone #-43-1-52177-295, 296, or 499, **fax** #-43-1-52177-364, **e-mail** vogelsammlung@nhm-wien.ac.at, anita.gamauf@nhm-wien.ac.at, hans-martin.berg@nhm-wien.ac.at **webpage** www.nhm-wien.ac.at/nhm

staff responsible for bird coll. Dr Ernst Bauernfeind (head), Dr Anita Gamauf, Hans-Martin Berg, Dr Herbert Schifter (retired, volunteer)

total staff of bird dept. 1 head, 1 ass. curator, 1 secretary, 1 taxidermist

brief history Founded in 1793 by Emperor Franz I of Austria, when he acquired the coll. of his retired falconer J. Natterer; now government-owned; oldest specimens from James Cook (2nd voyage, c.1773)

references to history, collections, or types von Pelzeln (1870, 1873, 1890), von Pelzeln & Lorenz (1886-88), Keve (1948), Keve & Rokitansky (1966), Schifter & Van den Elzen (1986), Schifter (1990, 1992a,b, 1993, 1994, 1996), Bauernfeind (1995), Schneider & Bauernfeind (1998), Schifter & Violani (1999)

important past bird staff Joseph Natterer Sr. & Jr., J. Heckel, A. von Pelzeln, J. Zelebor, C. E. Hellmayr, C. von Schreibers, F. Steindachner, L. Lorenz von Liburnau, M. Sassi, G. Niethammer, G. von Rokitansky, H. Schifter

important collections come from Graf Almásy, F. L. Bauer, W. Bojer, C. L. Brehm, W. Bullock coll. [which included part of the colls. of J. Banks, James Cook, J. R. & G. Forster, J. Latham, G. Montagu, R. Solander, W. Swainson, Voy. Endeavour, Voy. Resolution; these colls. in part from the former Mus. Leverianum. The Bullock coll. was sold in 1819 to the museums of Berlin, Edinburgh, Glasgow, Leiden, Paris and Turin, and to the private colls. of the Earl of Derby (now in Liverpool), Sabine, W. Swainson, N. Vigors, etc.], F. Deppe, R. von Dombrowski, C. W. R. van Duivenbode, Emin Pascha [see Bremen], O. Finsch, A. Fischer, G. W. Freyreiß, L. von Führer, R. Grauer, J. von Haast, J. Hector, T. von Heuglin, F. von Hochstetter, D. S. Hoedt, C. von Hügel, J. Jacquin, P. Knoblecher, T. Kotschy, M. Markl, A. B. Meyer, H. Möschler, Mus. Berlin (Lichtenstein, Hemprich & Ehrenberg), Mus. Leiden (Temminck, Schlegel), Mus. Leverianum [with the colls. of A. Lever, J. Banks, J. Cook, J. R. & G. Forster, R. Solander, Voy. Endeavour, Voy. Resolution. The Lever Museum coll. was sold in 1806 to, among others, the Wien Mus., to the Earl of Derby and from there to Liverpool Mus., and to W. Bullock], Joh. Natterer, E. Parzudaki, Ida Pfeiffer, J. Polatzek, N. M. Przhevalskii (duplicates), A. Reischek, O. Reiser, G. Schiebel, C. J. W. Schiede, F. Schillinger, W. Schimper, J. von Seilern, F. Sellow, F. Stoliczka, R. Swinhoe, J. J. von Tschudi, V. Tschusi zu Schmidhoffen, Underwood, Verreaux, Voy. Novara, E. Weiske, O. von Wettstein, Zimmer, and many others

approx. nr. of bird skins 104,300 (incl. c.10,000 mounts); c.7,000 species

other bird items 8,000 skeletons, 10,000 egg sets, 1,000 nests, many feather sets, a bone reference coll., bird sound recordings, etc.

approx. recent annual increase in skins 500–1,000, from local birds skinned by own taxidermist, donations, and buying of colls.

bird skin collection specialised in Austria, Hungary, Balkan countries, Jan Mayen, Egypt, Sudan, Ethiopia, C & E Africa, Madagascar, Himalayas, Tibet, S India, Sri Lanka, Philippines, Sulawesi, Ambon, Australia, Norfolk Isl., New Zealand, C & S America (especially Brazil: over 13,000 skins from Natterer, etc), Haiti; over 1,000 types (list in preparation)

card or computer system present skeletons and mounts on card and computer; most eggs on computer, but only 10% of skins

Wiesbaden (MWHN)

Info from: Fritz Geller-Grimm, 6 Dec 2001

address Landesmuseum Wiesbaden, Naturwissenschaftlichen Sammlung, Friedrich-Ebert-Allee 2, D-65185 Wiesbaden, Germany.

telephone #-49-611-335-2170/ -2178/ -2182, **fax** #-49-611-3352192, **e-mail** nws@museum-wiesbaden.de, fritz@geller-grimm.de

staff responsible for bird coll Dr Volkert Rattemeyer (head), Fritz Geller-Grimm (coll. manager/taxidermist)

total staff of bird dept. 2 (for entire vertebrate coll., see above)

brief history Founded 1829; owned by the government

references to history, collections, or types Römer (1863, 1879, 1892), Lampe (1904–1912)

important past bird staff C. Fetzer, E. Lampe, F. Neubaur, A. Römer, E. Zenker

important collections come from A. A. Bruijn, C. Feldmann, A. Fischer, E. A. Fritze, B. Lyon, B. De Mons, J. W. von Müller, F. Odernheimer, O. Rau, C. Thomä, J. Weiler

approx. nr. of bird skins 6,800 (incl. mounts)

other bird items 150 (partial) skeletons, 6,000 egg sets, 100 fossil birds

approx. recent annual increase in skins 50

bird skin collection specialised in many areas, but mainly C Europe

card or computer system present All on card, computer in progress (soon on www.nws-wiesbaden.de/coll02.html)

Wilhelmshaven (IfV)

Info from: Prof. Dr F. Bairlein, 31 Jan 2000

address Institut für Vogelforschung 'Vogelwarte Helgoland', An der Vogelwarte 21, D-26386 Wilhelmshaven-Rüstersiel, Germany

telephone #-49-(0)4421-96890, **fax** #-49-(0)4421-968955, **e-mail** ifv@ifv.terramare.de **homepage** http://home.t-online.de/home/O.Hueppop-IFV/ifv-hp.htm

staff responsible for bird coll. Rolf Nagel (coll. manager), Franz Bairlein (director)

total staff of bird dept. 1 head, 5 scientists, 1 coll. manager, 1 taxidermist, 19 others (incl ringing staff and staff for migration studies and ecological research)

brief history Founded in 1843 by Heinrich Gätke on Helgoland, moved to Wilhelmshaven in 1947; owned by government of Niedersachsen

references to history, collections, or types H. Bub (1985) *Orn. Mitt.* 37: 38-47.

important past bird staff H. Weigold, R. Drost, F. Goethe, H. Bub

important collections come from Nordseemuseum Helgoland , Heinrich Gätke, Hugo Weigold

approx. nr. of bird skins 5,500 (550 species), incl. many mounts (on show in Heinrich-Gätke-Halle)

other bird items 300 partial skeletons (skulls, sternums, etc), many eggs of c.270 species, 120 nests

approx. recent annual increase in skins 75, from local birds skinned by own taxidermist

bird skin collection specialised in Germany, China; migratory birds

card or computer system present partly on computer (system old)

Wroclaw (MPUW)

Info from: T. Stawarczyk, 31 Jan 1995

address Muzeum Przyrodnicze (Museum of Nat. Hist.), Uniwersytet Wroclawski (Univ. of Wroclaw), Sienkiewicza 21, 50-335 Wroclaw, Poland

telephone #-48-71-3754149, **fax** #-48-71-3225044, **e-mail** tomilu@biol.uni.wroc.pl

staff responsible for bird coll. Prof. Ludwik Tomialojc (head), Dr Tadeusz Stawarczyk, Mr Jan Lontkowski (coll. managers)

total staff of bird dept. 1 head, 2 coll. managers

brief history Founded in 1814 by J. L C. Gravenhorst; now part of University of Wroclaw

references to history, collections, or types Gravenhorst (1832)

important past bird staff E. Grube, F. Tiemann, C. Zimmer

important collections come from P. Kollibay (2,500 skins), O. Natorp, W. Volz, etc.

approx. nr. of bird skins 12,000 (2,000 species)

other bird items 136 skeletons, 2,000 egg sets

approx. recent annual increase in skins 5–10, from local birds skinned by own staff

bird skin collection specialised in Poland, Palearctic, Java, Sumatra, New Guinea, Brazil

card or computer system present none

Zagreb (ZZO)

Info from: Davor Cikovic, 20 Dec 1999
address Zavod za Ornitologiju /Institute of Ornithology (ZZO), Hrvatske Akademije Znanosti i Umjetnosti, Ilirski trg. 9, 10000 Zagreb, Hrvatska (Croatia)
telephone & fax #-385-1-4851 322, **e-mail** zzo@hazu.hr
staff responsible for bird coll. Davor Cikovic, BSc.
total staff of bird dept. 5 scientists (Dr G. Susic, Dr J. Muzinic, Dr V. Tutis, J. Kralj, D Radovic), 1 curator (D. Cikovic)
brief history Founded 1938, with A. Mastrovic as first director; part of the Croatian Academy of Sciences and Arts
references to history, collections, or types Susic *et al.* (1988), Crnkovic *et al.* (1993)
important past bird staff D. Rucner, R. Kroneisl-Rucner, K. Igalffy, S. Ivkovic, A. Ilic, K. Leskovar, R. Crnkovic
important collections come from A. Mastrovic, A. Ilic (eggs)
approx. nr. of bird skins 6,700 (317 species)
other bird items 557 egg sets (274 species)
approx. recent annual increase in skins 2
bird skin collection specialised in Former Yugoslavia (mainly Croatia)
card or computer system present all on card

Zürich (ZMUZ)

Info from: J. Hegelbach, 25 Jun 1996
address Zoologisches Museum der Universität Zürich-Irchel, Winterthurerstraße 190, CH-8057 Zürich, Schweiz / Switzerland
telephone #-41-1-257-4750, **fax** #-41-1-364-0295, **e-mail** hegzm@ zoolmus.unizh.ch
staff responsible for bird coll. Dr Johann Hegelbach (head), Prof. Dr V. Ziswiler (retired, volunt. assoc.)
total staff of bird dept. 1 head, 0.5 taxidermist
brief history —
references to history, collections, or types no publications
important past bird staff H. Steiner, K. Immelmann
important collections come from H. Möschler, etc.
approx. nr. of bird skins 4,000 (1,000 species)
other bird items 50 skeletons, 50 in alcohol, 800 egg sets
approx. recent annual increase in skins 50, from local birds skinned by own taxidermist and donations
bird skin collection specialised in —
card or computer system present all skins on card, part on computer

The 'B-list'

In this list, some smaller collections are mentioned which have fewer than *c.*4,000 skins, or fewer than *c.*5,000 bird items, or of which no exact information could be obtained because the questionnaire was not returned, even after repeated asking. At least addresses are mentioned, as well as some other details as far as known. Some of these collections may belong on the 'A-list'. As indicated there, collections with a smaller number of birds may not necessarily be less important, because they still may include types, rarities or birds from relatively unknown regions not represented in larger museums.

Açores Museu Carlos Machado (MCM), Rua de Santo André, Apartado 258, P-9503 Ponta Delgada (São Miguel), Açores, Portugal. Contains a small bird coll.

Aarhus Naturhistoriska Museum, Bygning 210, Universitetsparken, DK-8000 Århus-C, Denmark. Curator: Poul Hansen (e-mail: poulh@naturhist.aau.dk). Has a small coll. of bird skins. Former curator: Paul Bondesen.

Akureyri Akureyri Museum of Natural History, PO Box 580, IS-602, Akureyri, Iceland. Contains a small bird coll.

Augsburg Naturmuseum und Planetarium Augsburg, Im Thäle 3, Augsburg, Germany. Tel. #-49-821-324-6730, fax –6741. Head: Dr Michael Achtelig. Includes a small bird coll.

Autun Musée d'Histoire Naturelle de Ville d'Autun, 12-14 rue Saint Antoine, F-71400 Autun, France. Conservator: Gilles Pacaud. Includes a small bird coll.

Bacau Muzeul Judetean Bacau, Sectia Stiintele Naturii, Str. Karl Marx 2, Bacau, Romania. The bird coll., founded in 1959 and with entries from 1962 onwards, held c.2300 skins and skeletal items by the end of 1979, largely obtained by Dr Catalin Rang and largely from the Bacau area, but also from the eastern Carpathians and the Danube delta; also, 104 birds from Kisangani and Kivu in Congo. See Rang (1980).

Bad Dürkheim Pfalzmuseum für Naturkunde (PMN), Pollichia-Museum, Hermann-Schäfer-Straße 17, D-67098 Bad Dürkheim, Germany. Tel. #-49-6322-9413-0 or -23, fax –941311. Curator of zoology: Dipl.-Biol. Roland van Gyseghem (R.Gyseghem@ pfalzmuseum.bv-pfalz.de), former curator G. Groh. Founded 1840. Contains the coll. of the Pollichia (Verein für Naturforschung und Landespflege), which includes 100 bird skins, 50 skulls, 18 birds in alcohol, 300 egg sets, 50 nests, and a number of mounted birds, mostly from the Rheinland-Pfalz region, not on card or computer.

Bamberg Naturkunde-Museum Bamberg (NKMBA), Fleischstraße 2, D-96047 Bamberg, Germany. Tel.: #-49-951-86312-48. Head of coll.: Dr Matthias Mäuser (matthias.maeuser@en.uni-bamberg.de). Founded in 1792 by the archbishop Franz Ludwig von Erthal, now owned by the Lyzeum's foundation Bamberg, supervised by the Bavarian States Collections of Natural Science. Has 1,550 mounted birds (800 species), 31 (partial) skeletons, 552 eggs, and 112 nests, with data and photographs of all mounts on computer. Important past staff members D. Linder, A. Haupt, G. Fischer, T. Schneid, A. Kolb; coll. included specimens from Amalie Dietrich, J. C. Godeffroy, J. Natterer, J. L. Schönlein, J. B. von Spix, C. T. E. von Siebold, W. Schlüter, J. H. C. Sturm, and E. Weiske. See Jaeck (1815), Mäuser (1995a,b), and Steinheimer (in press a).

Bari, Italy. In the city are 2 small separate bird colls., one of which is the historical De Romita collection, quite famous in the past (N. Baccetti per. comm.) See also *Suppl. Ric. Biol. Selvaggina* 22 (1995).

Bialywieza This village in the centre of the Bialowieza Reserve in NE Poland has a small museum which includes 950 skins and mounts of birds (130 species) and 335 eggs of local origin.

Bielefeld Naturkunde-Museum der Stadt Bielefeld, Kreuzstraße 20, D-33602 Bielefeld, Germany. Tel. #-49-521-516734, fax –512481, e-mail NaturkundeMuseum@ bielefeld.de. Head: Dr Peter R. Becker. Includes a small bird coll.

Birchington Quex House & Gardens, the Powell-Cotton Museum, Quex Park, Birchington, Kent C17 0BH, U.K. One curator, partly dedicated to natural history. Includes many mammal skeletons, but also bird skins, eggs, and mounts in dioramas, mostly from Africa; many skins of Spheniscidae obtained from E. Shackelton's Antarctic Expeditions. (F. Steinheimer *in litt.*). See also Powell-Cotton (undated).

Birmingham Birmingham Museum and Art Gallery (BMAG), Chamberlain Square, Birmingham B3 3DH, U.K. Tel.: #-44-121-3034510, fax –3031315. Head of curatorial services: Dr Jane Arthur (jane_arthur@ birmingham.gov.uk). Natural History part opened 1913 but based on colls. founded in the 1840s, e.g. of Queen's College and C. Beale; owned by Birmingham City Council. Former curators W. Ellis and W. H. Edwards, major colls. received of R. W. Chase, W. R. Lysaght, and J. B. Williams. Includes over 2,000 mounts and over 1,000 egg sets, mostly local but also from abroad (e.g. Toronto) and including extinct birds like *Pinguinus impennis* and *Nestor productus*; partly on card and computer. Access to coll. at moment restricted due to budgetary and staff constraints.

Bitov This town in the Czech Republic has a museum which contains 590 birds of 273 species.

Bordeaux Muséum d'Histoire Naturelle de Bordeaux, 5 Place Bardinaeau, F-33000 Bordeaux, France. Founded 1811. Includes a small historical coll. of birds.

Bratislava Slovenské Národné Múzeum (Slovak National Museum) (SNMBS), dept of Zoology, Vajanského nábrezie 2, SL-81436 Bratislava, Slovakia. Tel. #-421-7-366836, fax –366653. Curator: Branislav Matousek. Includes c.6,000 bird skins.

Brescia Museo Civica di Scienze Naturali, GRAN, Via Ozanam 4, I-25128, Brescia, Italy. Curator: Pierandrea Brichetti. Director: Dr Marco Tonon. Includes a bird coll.

Budisov Moravského Zemského Muzea, Budisov Castle, near Trebic, SW Moravia, Czech Republic. Has over 2,600 mounted birds of many species, provenance worldwide, including many from Seilern (E Asia, S

America) and the coll. of Adolf Schwab (Mistek). See Sutorova & Hanak (1996) for history, a catalogue, and other details.

Burgas Natural History Museum (NHMB), 30 Constantin Fotinov Str., 8000 Burgas, Bulgaria. Tel #-359-56-45855, fax #-359-56-843239. Founded 1962, belongs to the Municipality of Burgas. Curator: Dr Dimitrina Smilova; former head Alexander Prostov. Includes c.300 skins and c.500 mounts of c.200 species, all on a card system, including rarities like *Numenius tenuirostris*; also, a fair coll. of subfossil bird bones. See Prostov & Smilova (1983).

Bytom Upper Silesian Museum, Bytom, S-C Poland. Has 1,100 bird skins, 884 mounts, 140 (partial) skeletons, 3,821 eggs, and 234 nests, mostly from Poland but also 130 mounts from Borneo. Includes colls. of M. Bielewicz, E. Drescher, Gedroyc, O. Natorp, and S. Sobania.

Cagliari Instituto de Zoologia (IZUCS), Universita di Cagliari, Cagliari, Sardinia, Italy. Includes a small historical coll. of Sardinian birds.

Carlisle Tullie House Museum and Art Gallery, Castle Street, Carlisle CA3 8TP, Cumbria, U.K. Tel. #-44-1228-534781, fax –810249. Keeper of Natural Sciences: Stephen Hewitt (SteveH@carlisle-city.gov.uk). Founded in 1893, owned by Carlisle City Council. Important past staff members or persons donating colls: Rev. H. A. Macpherson, L. E. Hope, E. Blezard, Marjory Garnett, E. B. Dunlop, D. L. Thorpe, J. W Harris. Includes 2,500 skins, 1,500 mounts, 100 (partial) skeletons, and c.3,500 egg sets, virtually all from Carlisle and the Cumbria region.

Casalnuovo Monterotaro Museo Civico di Storia Naturale, Via Diaz, Casalnuovo Monterotaro, Foggia prov., Italy. Has a bird coll. of 1,350 mounts; see: *Suppl. Ric. Biol. Selvaggina* 22 (1995).

Catania Gemmellaro State Institute, Catania, Sicily. For a catalogue of its small bird coll., see : A. Cantarero (1993) *Naturalista Siciliano* 17: 183-185.

Çeska Lípa Okresní Vlastivedné Muzeum, nam Osvobozeni 297, CZ-470 01, Çeska Lípa, Czech Republic. Tel.: 00-420-425-22791, 22854 & 22843. A former monasatery coll. including local and exotic bird mounts.

Chemnitz Museum für Naturkunde, Theaterplatz 1, D-09111 Chemnitz, Germany. Tel. #-49-371-4884551, fax –4884597, e-mail naturkundemuseum@ stadt-chemnitz.de. Mainly geological/entomological, but includes a small bird coll.

Chieri A museum in Piedmont prov., Italy. Contains the Villa Brea coll.; for a catalogue of the small bird coll., see G. Aimassi & L. Levi (1993) *Riv. Piemontese di Storia Naturale* 14: 217-230.

Cluj-Napoca Zoological Museum, Dept. of Biology, University of Cluj-Napoca, Ro-3400 Cluj-Napoca, Romania. A coll. founded 1859, which had 1,146 birds in 1964 (of 396 species). Former curator a.o.: L. von Führer. See Gherghel (1988, 1989).

Coventry Herbert Art Gallery and Museum (HAGM), Jordan Well, Coventry CV1 5QP, U.K. Tel.: #-44-2476-832374, fax –832410. Keeper of Natural History: Steve Lane (steve.lane@coventry.gov.uk). Founded 1949, part of Coventry City Council. Has 250 skins and mounts and 4,500 eggs with data (and at least 5,000 more without), all on computer. Includes the colls. of, e.g. Nicholls, Betteridge, Beddall-Smith (eggs), Bellgrove (eggs), and Ground (eggs), mostly of local origin (Warwickshire) or from the U.K. generally.

Cruz Quebrada-Dafundo Aquario Vasco da Gama, 1495 Cruz Quebrada-Dafundo, Portugal. Head: Dr Aldina Moreira Inácio. The aquarium also has a small bird coll.

Czestochowa Muzeum Okregowe, Al. Najswietszej Marii Panny 45a, PL-42-200 Czestochowa, SC Poland. Tel.: #-48-34-3244424, fax #-48-34-3243275. Contains 135 bird skins and mounts (119 species) and 567 eggs.

Darmstadt Hessisches Landesmuseum (HLMD), Zoologische Abteilung, Friedensplatz 1, D-64283 Darmstadt, Germany. Tel. #-49-6151-165703, fax –28942. Curator Dr U. Joger. Includes many local birds from Hessen, the large former coll. of J. J. Kaup, and some material of F. Brüggemann, J. Gundlach, C. F. H. von Ludwig, H. von Rosenberg, and many others. For history, see: R. Kuhn (1993) *Collurio* 11: 36-47.

Dijon Muséum d'Histoire Naturelle, Pavillion de l'Arquebuse, 1 Avenue Albert 1er, Dijon, France. A large show coll. with dioramas.

Dobrich (Tolbukhin) Cultural and Historical Heritage, Direction of Tolbukhin, Bulgaria. Tel #-359-58-24463. Contains a small coll. (228 birds, 178 species) from the Bulgarian part of the Dobrogea region, all well-registered. See Nonev (1982).

Dortmund Museum für Naturkunde, Münsterstraße 271, D-44145 Dortmund, Germany. E-mail: naturkundemuseum@ stadtdo.ge. Founded 1912. Includes a small bird coll.

Dublin Natural History Museum/Músaem na Staire Nádúrtha, National Museum of Ireland (NMI), Merrion Street, Dublin 2, Ireland. Tel: #-353-1-6777444, fax –6761348, e-mail nmi@indigo.ie. Curator for all non-entomological zoology Dr Mark Holmes, education officer Dr Damien Walshe (spare-time occupying with bird coll.). Founded 1857. Includes the coll. of O'Mahorey.

Ekaterinburg Institute of Zoology, Russian Academy of Sciences. Curator: Vadim K. Ryabitsev (riabits@etel.ru). An important coll., but not included in the main list because Ekaterinburg is just within Asia, not Europe.

Elverum Norsk Skogsbruksmuseum, P.O. Box 117, N-2401 Elverum, Norway. Tel. #-47-624-10299, fax –13015. Curator Mr Andersen. Has a small bird coll.

Erlangen Institut für Zoologie, Erlangen Universität, Staudstraße 5, D-91058 Erlangen, Germany. Has a small bird coll. which includes, for instance, 2 *Ectopistes migratorius*. Head of Institute: Prof. Dr O. von Helversen.

Essex Saffron Walden Museum (SWM), Museum Street, Saffron Walden, Essex CB10 1JL, U.K. Curator of Natural Sciences: Sarah Kenyon, tel/fax #-44-(01)799-510333, e-mail museum@ uttlesford.gov.uk. Founded 1832 by the Saffron Walden Natural History Society. Founders and former staff include Lord Braybrook, Clarke, Gibson, and Maynard. Contains 1,500 mounts and skins of birds (mostly British/ European, partly mounted by J. Gould and Leadbeater, but also foreign: Asia, Australia, N & S America, Africa) and 6,540 eggs (e.g. the Tuke and Smith colls., mainly British), largely collected in the nineteenth century.

Fermo Museo di Scienze Naturali, Fermo, Italy. Includes 408 mounted Italian birds of the private coll. of T. Salvadori, donated by him to the city of Fermo in 1930. See *Suppl. Ric. Biol. Selvaggina* 22 (1995), and Violani *et al.* (1997); in the latter work, all birds are shown on photographs.

Ferrara Istituto di Zoologia e Biologia Generale, Università degli Studi di Ferrara, Via Previati 24, I-44100 Ferrara, Italy. Contains c.2,000 skins and mounts: see S. Mazzotti & S. Volponi (1993) *Museol. Scientifica* 10: 53-61.

Forli Museo Ornitologico 'F. Foschi', Forlì, Emilia Romagna prov., Italy. Contains the coll. of F. Foschi (assembled 1934–1980) of c.3,500 mounts of Italian birds, and includes also several older colls. See U. F. Foschi ('1993'=1994) *Museol. Scientifica* 10: 335-336. A 112 pp. catalogue was published by U. F. Foschi in 1984.

Funchal Museu Municipal do Funchal (Historia Natural) (MMF), Ornithology section, Rua da Mouraria 31, 9000 Funchal, Madeira, Portugal. Tel. #-351-91-792591, fax –225180. Curator (for entire zoology) E. C. Gerrard ('Ted') (egerrard@ tethys.uma.pt). Founded by Padre E. Schmitz, now owned by municipality of Funchal. A small but important coll. of birds from Madeira and other Atlantic islands

Göttingen Zoologisches Museum (ZIMG), Institut für Zoologie und Anthropologie der Universität Göttingen, Berliner Straße 28, D-37037 Göttingen, Germany. Tel. : #-49-551-395524, fax –395579. Curator: Dr Gert Tröster (gtroest@gwdg.de). Includes colls. of the past staff members J. F. Blumenbach, Ehlers, and H. Kirchhoff. The bird coll. has c.350 mounts and 1,350 skins, and includes extinct birds like *Ectopistes migratorius*, *Nestor productus* and *Conuropsis carolinensis*; also, 300 egg sets and a few skeletons

Graz Steiermärkisches Landesmuseum Joanneum (LMJ), Raubergasse 10, A-8010 Graz, Austria. Tel #-43-316-8017 9760, fax #-43-316-8017 9800, e-mail post@lmj-zoo.stmk.gv.at, webpage www.museum-joanneum.at. Manager of bird coll.: Peter Sackl; a former curator A. von Mojsisovics. Founded 1811, belongs to the Steiermark government. Includes 1,756 skins (700 species), 150 skeletons (60 species), 350 egg sets, and 100 nests, including parts of the former colls. of von Spix, Tschusi zu Schmidhoffen, Worofka, Johann Natterer, Schiebel and Neunteufel, both from Austria and abroad, of which part is on computer; increase c.20 skins annually, from local birds skinned by own taxidermist. See Marktanner-Turneretscher (1911) and Mecenovic (1969) for history and contents of the coll.

Greifswald Zoologisches Institut und Museum, Ernst-Moritz-Arndt-Universität Greifswald, Johann-Sebastian-Bach-Straße 11-12, D-17489 Greifswald, Germany. Tel. #-49-3834-864271, fax – 864252, e-mail zool.museum@uni-greifswald.de. Curator: Dr Dietmar Schittek. Includes an important number of bird skins.

Härnösand Länsmuseet Murberget, S-87102 Härnösand, Sweden. Tel. #-46-611-23240. Has a small bird coll.

Heusden-Zolder The large coll. of mounted birds of Pater Landewald Jansen is exhibited in Heusden-Zolder, prov. Limburg, Belgium. Info: Stichting Limburgs Landschap, tel. #-32-11-530250.

Hildesheim Roemer-Museum, Am Steine 1-2, D-31134 Hildesheim (near Hannover), Germany. The coll. is mostly archaeological, but a small coll. of birds is available. See Schoppe (1987) for history and contents.

Hradec Králové Muzeum Vychodních Czech, Nat. Hist. Dept., Eliscino nábrezí 465, CZ-50001 Hradec Králové, Czech Rep. Tel. #-42-49-5514631, fax #-42-49-5512899. Curator Dr Karel Lohnisky, former curator V. Balthasar. Includes 450 skins (300 species, 55 bird families), 450 skeletons (300 species), and 50 egg sets, largely from Czech Rep. and Slovakia

Innsbruck Institut für Zoologie und Limnologie (IZUI), Abt. Terrestische Ökologie und Taxonomie, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria. Head of Institute: Dr Konrad Thaler. The coll. of the institute was founded in about 1860, and now includes c.330 mounts, at least 12 skeletons, and a few birds in alcohol, skulls, egg sets, and nests.

Istanbul Robert's College (Istanbul Amerikan Robert Liseri), PK 1 Arnavutkai, TR-80820 Istanbul, Turkey. Contains 266 mounted birds (174 species), presumed to be largely of local origin. Based on the private coll. of T. Robson (an inhabitant of Istanbul 1861–1871), with later additions by Mathey-Dupraz and others. In poor condition, with at least 265 specimens lost between 1924 and 1996. See Mathey-Dupraz (1920–1924) and Kirwan (1997).

Jelenia Góra The suburb Cieplice of this town in SW Poland has a small natural history museum which includes 922 skins and mounts of birds (370 species), 541 eggs, and 30 nests.

Jokkmokk Ájtte Svensk Fjäll- och Samemuseum, S-96040 Jokkmokk, Sweden. Tel. #-46-971-17070. Has a small bird coll.

Jönköping Ornithological Museum, Town Park, Jönköping, Sweden. Open May–August; owned by Jönköping Municipality. Contains 1,458 mounts and skins (of 341 species) and 2,580 eggs (of 281 species), largely of birds from Sweden. Based on donations of H. Nyqvist in 1914 (mounts & skins) and E. Wibeck in 1943 (eggs). See Berlin (1988).

Kassel Naturkunde Museum im Ottoneum, Steinweg 2, D-34117 Kassel, Germany. Tel. #-49-561-7874014, fax –7874058. Info: Dr Franz Malec or Dr Peter Mansfeld. Founded 1884. Includes a small bird coll., with material of, e.g., J. Gundlach (Cuba) and Matzko, and with extinct birds like *Ectopistes migratorius* and *Conuropsis carolinensis*.

Kazan Zoological Museum of the Kazan State University, Tatarstan, Russia. Curator: Tatyana Vodolazskaya (e-mail: Tatjana.Wodolazskaya@soros.ksu.ru). Founded 1804, with K. Fuchs as first head, later succeeded by E. F. Eversmann. Has 500 skins and 1,000 mounts of birds from the colls. of E. A. Eversmann, M. D. Ruzskiy, A. A. Ostroyumov, E. Pelzmann, etc.

Kendal Kendal Museum, Station Road, Kendal LA9 6BT, Cumbria, U.K. Tel.: #-44-1539-721374, fax –722494. Ass. Keeper: Morag Clement. Founded 1796, owned by local government. Has large dioramas with mounted birds, both local (Lake District) and exotic; also, a small egg coll.

Kiev The coll. of the Zoological Museum of Kiev University (ZMKU) was destroyed in World War II and the museum apparently does not function as such now. The other museum in Kiev, the Zoological Museum of National Academy of Sciences of Ukraine (ZMAU), is in the 'A' list.

Kosice Vychodoslovenské Múzeum Kosice (VSM), Prírodovedné oddelenie, Hviezdoslavova 3, 04136 Kosice, Slovakia. Curator: Dr Miroslav Fulín. Founded 1955; state-owned. Specialised in the Carpathian region of Slovakia. Includes 2,000 bird skins, 1,000 mounts, 3,000 (partial) skeletons, 50 birds in liquid, and 1,200 egg sets, to which c.20 are added annually; includes the coll. of A. Mosansky. For details and catalogues of the coll. see various issues of *Zborník*

Vychodoslovenského Múzea (e.g. 1977 and 1978) or Matousek & Mutkovic (1985).

Köthen Naumann Museum, Köthener Schloss, Schloßplatz 4 (P.O. Box 181), D-06366 Köthen, Germany. Tel. #-49-3496-212074. A large mounted coll., obtained mainly in the first half of the nineteenth century and still in its original setting. Founded by J. A. & J. F. Naumann, acquired by August Herzog von Anhalt-Köthen in 1821, with J. F. Naumann as first director, later on succeeded by Edmund Naumann. Also, includes the feather coll. of W.-D. Busching, many birds from G. Garlepp (South America), etc. See W. Zimdahl (1980) *Falke* 27: 42-44.

Kristiansand Agder Naturmuseum og Botanisk Hage, Gimlegård, Gimleveien 23, N-4687 Kristiansand, Norway. Tel. #-47-380-92388, fax –92378. Head curator Roar Solheim (roar.solheim@agder-natur.museum.no). Has a small bird coll.

La Rochelle Museum d'Histoire Naturelle de La Rochelle (MHNLR), 28 Rue Albert 1-er, F-17000 La Rochelle, France. Tel. #-33-546-41825, fax –506365. A small historical coll., which includes extinct birds like *Rhodonessa caryophyllacea*, *Ectopistes migratorius*, and a skeleton of *Raphus cucullatus*.

Leeuwarden Fries Natuurmuseum (FNM), Schoenmakersperk 2, NL-8911 EM Leeuwarden, Netherlands. Curator: Johannes Fokkema. Tel. #-31-58-2129085, e-mail info@friesnatuurmuseum.nl. Includes 3,500 birds and c.1,000 eggs, virtually all from the province of Friesland.

Le Havre Muséum du Havre, Le Havre, France. Includes 744 birds of the coll. Dubois/Hemery, obtained by Maury; Lesueur was curator in the 1840s, but his and other historical colls. were lost after bombing in 1944.

Leicester New Walk Museum, Leicestershire Museums, 53 New Walk, Leicester LE1 7EA, U.K. Tel.: #-44-116-2554100, fax –2473057. Curator of biology: Derek Lott. Includes a small bird and egg coll.

Livorno Museo di Storia Naturale del Mediterraneo (formerly Museo Provinciale di Storia Naturale di Livorno), Via Roma 234, I-57127 Livorno, Italy. Tel. #-39-586-802294. A small coll., including c.1,000 bird skins, mainly from Tuscany. Catalogue: E. Arcamone & E. Meschini (1981) *Quaderni Mus. Stor. nat. Livorno* 2, 65-94.

Ljubljana Prirodoslovení Muzej Slovenije (ML), Presernova 20, p.p. 290, SI-1001 Ljubljana, Slovenia. Curator for birds: Janez Gregori (jgregori@pms-lj.si; tel. 01-2410947. Founded 1905, government-owned. The bird coll. has 3,500 skins and 125 eggs, to which 100–150 birds are added anually; most birds are from Slovenia, but some recent colls. from Macedonia, Dalmatia, and Nepal. It includes colls. of Lojze Smuc, Janez Dovic, and Dare Sere.

London Grant Museum of Zoology and Comparitive Anatomy (formerly: Zoology Museum), Biology Dept, Darwin Building, University College London, Gower Street, London WC1E 6BT, U.K. Tel #-44-171-387-7050 or -2647, fax#-44-171-380-7096. Curator Ms Helen Chatterjee (h.chatterjee@ucl.ac.uk), lecturer Dr Adrian Lister; former curator Ms Rozina Down. Founded 1828 when the private coll. of Robert E. Grant was added to that of the Imperial College; now part of University College London. Contains 550 bird skeletons and anatomical specimens.

London Museum of the Royal College of Surgeons of England (RCSE), 35-43 Lincoln's Inn Fields, London WC2A 3PN, U.K. Curator of vertebrates: Barry Davis (tel. ##-44-171-973-2190, fax ##-44-171-405-4438, e-mail museums@rcseng.ac.uk or bdavis@rcseng.ac.uk). Founded in 1799 when the British Government purchased the coll. of John Hunter, becoming the Royal College of Surgeons in 1800; coll. opened to the public in 1813. Heavily damaged in World War II, but some 500 anatomical bird specimens remain, mostly in spirit, many from the eighteenth century. All bird items on computer (F. Steinheimer *in litt.*).

Lübeck Naturhistorisches Museum Lübeck, Mühlendamm 1-3, D-23522 Lübeck, Germany. Head: Dr Wolfram Eckloff. Includes a small bird coll. Formerly had material from North America and SE Asia, e.g. the coll. of Hugo Storm, but this was destroyed in 1942.

Ludlow Shropshire County Museum Service (SHRCM), Ludlow Museum Office, 47 Old Street, Ludlow SY8 1NW, Shropshire, U.K. Tel: #-44-1584-873857, fax –872019, e-mail ludlow.museum @shropshire-cc.gov.uk. Curator of Natural Sciences: Ms Katherine J. Andrew. Founded 1833; has 550 mounted birds, a further 40 cases of mounted birds, 10 (partial) skeletons, and 3,000 eggs, including material from the Whitchurch Museum, the Ludlow Nat. Hist. Soc., and the John Rocke private museum (Clungunford), mostly from the Shropshire region (W England) and the British Isles generally.

Luxembourg Musée National d'Histoire Naturelle de Luxembourg (MNHNL), 25 Rue Münster, L-2160 Luxembourg. Tel. #-352-462233-200 or –462233-414. Curator of the zoological section: E. Engel (eengel@mnhn.lu), scientific assistant J.-M.Guinet (jmguinet@mnhn.lu; tel –462240-209); former curator V. Ferrant. Has 2,500 mounts (many with full data), 104 skins, 55 skeletons/skulls, c.300 eggs, 240 nests, and 81 feather sets; includes colls. of H. Linden, E. Holub, H. Princess von Schwartzenberg, and J. Saur, both of local origin and from Africa and South America (e.g. from Brazil). See Ferrant (1912) and Guinet (1999) for catalogues.

Lyon Musée Guimet d'Histoire Naturelle (MGHNL), Museum de Lyon, 28 Boulevard des Belges, F-69006 Lyon, France; tel. #-33-472-690519. Curator: M. Clary, G. Pacaud. Founded 1772 and containing many mounts of birds. The Centre de Paléontologie stratigraphique et Paléoecologie, ERS 2042, Université Claude Bernard-Lyon 1, 27-43 Boulevard du 11 Novembre, F-69622 Villeurbanne Cedex, France, has an enormous coll. of (sub)fossil and recent bird bones (curator: Dr Cécile Mourer-Chauviré).

Maastricht Natuurhistorisch Museum Maastricht (NHMM), Postbus 882, NL-6200 AW Maastricht, the Netherlands (visitors address: De Bosquetplein 6-7, NL-6211 KJ Maastricht). Tel. #-31-43-3505477, fax – 3505475. Head curator: Ms Drs F. N. Dingemans-Bakels. Founded 1912, owned by local government; includes colls. of A. W. P. Maessen, pater Nillesen, and Mr Knapen (eggs). Has 2,000 skins and mounts, 30 skulls, and 1,370 eggs, largely from the Limburg province, not all yet on card or computer.

Madrid The Universidad Autónoma de Madrid has an important avian skeleton coll.

Mainz Naturhistorisches Museum Mainz (NHMMZ), Landessammlung für Naturkunde Rheinland-Pfalz, Reichklarastraße 10, D-51116 Mainz, Germany. Tel #-49-6131-122647, e-mail snhmmz@mail.uni-mainz.de. Curator: Dr Ulrich Schmidt. Founded 1834; owned by city of Mainz. Has 2,875 skins and mounts, 1,025 (partial) skeletons, 1,875 egg sets, and 216 nests, all on card/computer; 10–50 skins are added annually. Regionally specialised (Rheinland-Pfalz), but also birds from elsewhere in C Europe and from Ruanda; includes birds of, e.g., O. Natorp.

Malmö Malmö Museer, Natural History Department, Malmöhus Castle, Malmöhusvägen, S-20104 Malmö, Sweden. Tel. #-46-40-344400. Founded 1841. Curator: Sverker Wadén (sverker.waden@malmo.se). Includes an important number of bird skins, mostly Swedish.

Marseille Muséum d'Histoire Naturelle de Marseille (MMNH), Palais Longchamp, F-13004 France. Has a small bird coll.

Melitopol State Pedological Institute, Melitopol, Crimea, Ukraine. A small bird coll. Curator Aleksander I. Koshelev (station@melitopol.net)

Monaco Musée Oceanographique (MOM), Avenue Saint-Martin, MC-98000, Monaco-ville, Monaco. Has fewer than 200 skins, mostly of sea-birds. Catalogue: C. Carpine (1986) *Bull. Inst. Oceanogr. Monaco* 1436: 1-73.

Montauban Muséum d'Histoire Naturelle de Montauban, Palais de la Cour des Aides, Place A. Bourdelle, F-82000 Montauban, France. Founded 1854, containing c.1,500 mounted local and exotic birds.

Moscow Biological Faculty of Moscow State University MGU, dept of Vertebrate Zoology. Includes colls. of bird skins and specimens in spirit. Curators: Maksim N. Dementiev (skins; demmaks@apexmail.com), Prof Felix Ya. Dzerzhinski (spirit specimens; dzer@soil.msu.ru)

Moscow Dept of Zoology and Ecology, Zoological-Chemistry Faculty, Moscow Pedagogical State University MPSU. Tel #-7-(0)95-283 1634. Curator: Vladimir T. Butiev. Founded 1959. Includes c.3,500 skins (c.600 species) from a wide area of the former USSR, all registered on a card system, with regular additions from own expeditions, local collectors, etc.

Moscow Geography Faculty, Dept of Zoogeography, Moscow State University MGU. Includes nearly 1,000 skins and c.400 clutches with nest. Curator: Dr Vladimir N. Kalyakin.

Moscow Private coll. of the late Dr L. S. Stepanyan [formerly associated with the Institute of Ecology and Evolution (former A. N. Severtzov Institute) (IOAN), Russian Academy of Sciences, Leninskii Prospekt 33, 117071 Moskva V-71, Russia. Staff: A. V. Filchagov]. This private coll., whose fate is unknown following the death of Stepanyan in 2002, was started in 1953 and includes 2,784 birds (c.600 species) obtained during expeditions to many sites in the former Soviet Union (especially the Caucasus and the Far East), as well as Mongolia, Vietnam, and the SW Pacific; 4 types are included. Catalogue: Stepanyan (2001).

Nancy: Muséum-Aquarium de Nancy (MAN), 34 rue Sainte-Catherine, F-54000 Nancy, France. Tel #-33-383-329997. Coll. manager: Dr Alain Philippot (alain.philippot@man.uhp-nancy.fr). Formerly named Museé de zoologie de l'Université et de la ville de Nancy (MZN), now belongs to the Communauté Urbaine du Grand Nancy. Founded in 1854; former staff members Mr Godron and L. Cuénot, includes the coll. of Charon and with large recent acquisitions as a depot of the Paris Museum (MNHN). Includes 3,000 mounts, a few skins and skeletons, and a fairly large number of egg sets. Mounts of worldwide provenance, all on computer.

Naples/Napoli Centro 'Musei delle Scienze Naturali' of the Istituto e Museo di Zoologia, Università degli Studi di Napoli Federico II, Via Mezzocannone 8, I-80134 Napoli, Italy. Curator: Nicola Maio. Founded in 1811 by G. Murat, now containing 2,230 skins and mounts, from Italy, Brazil, E Africa, etc.; includes colls. of Luigi Petagna, Achille Costa, Elena d'Aosta, and Mario Schettino. See Maio & Nappi (2001) *Avocetta* 25: 154, and *Avocetta* 23: 193 (1999).

Nice Musée d'Histoire Naturelle (Musée Barla), 60 Bd Risso, F-06300 Nice, France. Tel. #-33-4-93551524, fax –93558196. Has a small bird coll.

Nottingham Nottingham Natural History Museum, Wollaton Hall, Wollaton Park, Nottingham NG8 2AE, U.K. Tel: #-44-115-9153900, fax –0153932. Has a large egg coll.

Norwich Castle Museum, Nat. Hist. Dept., Norwich, Norfolk NR1 3JU, England, tel#-44-1603-493642, fax -765651. Curator of Natural History Dept: Dr A. G. (Tony) Irwin, e-mail tony.irwin.mus@norfolk.gov.uk. Includes large bird dioramas.

Novi Sad Institute for Protection of Nature of Serbia, Radnicka 20, 21000 Novi Sad, Yugoslavia. Tel #381-21-421144, e-mail ZZPSNS@eunet.yu. Curator Slobodan Puzovic MSc; 2 taxidermists. Founded 1947, government-owned. Includes 2,500 bird skins (200 species), 45 skeletons, 405 egg sets, 50 nests.

Novy Jicin This town in N Moravia (E Czech Republic) has a museum which contains 519 birds of 287 species.

Odessa Odessa State University, Odessa, Ukraine. Includes a small bird coll. Curator: Anatoli I. Korzyukov (olegk@te.net.ua)

Olomouc Vlastivedne Muzeum v Olomouci (regional Museum of Olomouc), Námestí Republiky 5, 77173 Olomouc, Czech Rep. Curator Zdenèk Vermouzek (tel. #-420-68-5515116/ 0605-578746; fax #-420-68-5222743, e-mail verm@vmo.cz). Founded by fusion of some smaller colls. 1873–1908; former curator Zdenèk Rumler. Has 3,000 skins, 1,500 (partial) skeletons, and 273 egg sets, to which up to 20–30 are added annually. Most items are from Moravia or the Czech Republic generally, a few exotic; all are on card, part also on computer. See also Varga (1973).

Opava Slezské Zemské Muzeum, Prirodovední oddelení, Tyrsova 1, 74646 Opava, Czech Republic. Includes 4,000 bird skins (Varga 1973).

Oporto see Porto

Oradea Muzeul 'Tarii Crisurilor', Str. Stadionului 2, 3700 Oradea, Romania. According to a catalogue (Kovats *et al.* 1970), the coll. contains 1,315 birds of 207 species. Also an egg catalogue is available (Beczy 1971).

Padua/Padova Museo di Zoologia, Università degli Studi di Padova, Via Jappelli 1/A, I-35121 Padova, Italy. Tel #-39-49-8275410, fax –8275064. Curator: Paola Nicolosi (paola.nicolosi@ unipd.it); scientific staff: Prof. M. Turchetto, Prof. R. Sandra Casellato (for all zoology). Founded 1734 with the donation of the coll. of Antonio Vallisneri to the university; includes colls. of G. Nardo and C. Acerbi from Italy, USA, and Egypt. Has at least 680 mounts (without data on stands, but perhaps to be traced from available ancient catalogues), 21 skeletons & skulls, 340 eggs and 98 nests (425 species), mostly from the local area (Veneto) but with some from elsewhere; not yet on computer. See also Nicolosi & Turchetto (2001).

Panagyurishte Town Historical Museum (NHMP), Panagyurishte, Bulgaria. Curator: Yasen Hristov. Founded 1970. Includes c.200 bird skins, mainly from nearby localities in C Bulgaria; all on card. See Hristov (1982).

Pavia Dip. Biologia Animale, Università di Pavia, Piazza Botta 9-10, I-27100 Pavia, Italy. Curator: Dr Carlo Violani. The coll. includes c.4,000 birds skins and mounts.

Pécs Janus Pannonius Museum, University of Pécs, Pécs, Hungary. Includes a small bird coll. For history, see: B. Solti ('1991'=1992) *J. P. Mus. Evkonyve* 36: 59-66.

Perpignan Muséum d'Histoire Naturelle, 12 Rue Fontaine Neuve, F-66000 Perpignan, France. Has a small bird coll.

Pleven Natural History Museum, 3 Stoyan Zaimov Str., 5800 Pleven, Bulgaria. Tel. #-359-64-23569. Curator: Ivan Raychev, former staff I. Iliev, G. Slavchev, V. Dimitrov. Founded 1958, belongs to Municipality of Pleven. Includes c.1,000 bird skins and 576 mounts, including rarities from the nearby region of NC Bulgaria; all in a card system. See Dimitrov (1981).

Plovdiv Natural Science Museum (NSMP), 34 Hristo G. Danov Str, 4000 Plovdiv, Bulgaria. Tel. #-359-32-264474. Curator: Prof. Tseno Petrov; former head Boris Kaltchev. Founded 1918, belongs to the Municipality of Plovdiv. Includes the former coll. of the College St. Augustin (Philipopol), obtained 1955. Includes 662 skins (250 species), largely from S Bulgaria. Card system available. See Petrov (1983).

Plzen Západoceske Muzeum, Knohova vymen, Kopeckého Sady 15, CZ-30000 Plzen, Czech Rep. Includes 500 skins. For the zoological coll., see: L. Hurka (1982) *Sbornik Zapodoceske Mus. Plzni* 41: 1-63.

Porto Museu de História Natural – Zoologia (MZP), Faculdade de Ciências do Porto, Praça Gomes Teixeira, P-4050 Porto, Portugal. Tel #-351-2-310290, fax #-351-2-2004777. Coll. manager Luzia Sousa, other staff Maria José Cunha. Founded in 1900 by Prof. Augusto Nobre; former staff Reis Júnior, J. R. dos Santos Júnior. Includes 200 bird skins and 4,000 other items.

Pristina Muzej Kosova i Metohije (500 PRI), Prirodnjacko Od., Trg. Kralja Milutina 13, 38000 Pristina, Kosovo, Yugoslavia. Tel. #-381-38-20611. Curator: Ms Basanovic. Founded 1951, government-owned. Includes 1,000 skins (157 species) from the Kosovo & Metohija region. The present status and future of the coll. is unknown; in late 1999, it was apparently unattended, as the curator was as a refugee in Beograd.

Randazzo A museum in Catania province, Italy. Includes the coll. of A. Priolo, with 2,250 mounted birds (389 species), mainly from E Sicily; see: *Suppl. Ric. Biol. Selvaggina* 22, 1995. Catalogue: Priolo & Di Palma (1995).

Ravenna Museo Ornitologico di Scienze Naturali del Comune di Ravenna (MOESN), Via Rivaletto 25, I-48020 Sant'Alberto (Ravenna), Italia (office address: Loggeta Lombardesca, Via di Roma 13, I-48100 Ravenna). Tel. #-39-544-482054, fax –212092, e-mail museo.ornitologico@comune.ravenna.it). Curator Dr Linda Kniffitz (tel. –482761), former curator Dr Azelio Ortali. Founded in 1906 by Alfredo Brandolini; donated to the Comune di Ravenna in 1967, together with the large ornithological library. Includes 2,000 birds of 69 families, 330 eggs, and 91 nests, mainly of regional origin (Emilio Romagna), but also a wide scatter of exotic of birds; several *Numenius tenuirostris*. See Brandolini (1961) and Ortali (1974) for a catalogue.

Regensburg Naturkunde Museum Regensburg, Am Prebrunntor 4, D-93047 Regensburg, Germany. Tel.: 00-49-941-5073446. Director and curator: Dr Hansjörg Wunderer. A small coll. of (mainly) local birds.

Reghin Lyzeum Nr 2, RO-4225 Reghin (Mures Co.), Romania. Former curator István Kohl. The coll. includes 3,516 birds of 386 species, of which 149 exotic, the remainder largely local, often in fairly large series; also includes many (partial) skeletons present. See Kohl (1990–1991). Also in Reghin is the private coll. of László V. Kalabér (26 Eminescu Str., RO-4225 Reghin; tel/fax #-40-65-520590), which includes 27 skins, 40 birds in alcohol, 2,217 eggs, and 471 nests of 125 European bird species.

Rennes Muséum National d'Histore Naturelle, Université de Rennes, Campus Beaulieu, F-

35042 Rennes, France. Curator: Dr L. Marion. Includes a small bird coll.

Rimini Riserva Naturale Orientata e Museo Naturalistico di Onferno, Comune di Gemmano, Piazza Roma 1, I-48855 Gemmano, Rimini, Italia. Curator: Dino Scaravelli. Includes 660 mounted birds, mainly from the region but with some from elsewhere in Italy or Europe. See Scaravelli (2001)

Rostock Zoologischen Sammlung der Universität Rostock (ZSRO), Institut für Allgemeine und Spezielle Zoologie, Rostock, Germany. Head of institute: Prof. Dr R. K. Kinzelbach. Founded 1775 by O. G. Tychsen, includes colls. of A. Ch. Siemssen, G. Lembcke, H. Wachs, R. Kuhk, F. Hamann (eggs), and F. J. H. von Müller; contains c.800 bird objects, mainly mounts and eggs (catalogue: www.biologie.uni-rostock.de/zoologie/sammlung/voegel). See: Kinzelbach *et al.* (1997).

Rouen Museum d'Histoire Naturelle de Rouen, 198 rue Beauvoisine, F-76000 Rouen, France. Founded 1828 by F.-A. Pouchet; fairly large (1 million zoological items), but closed for security reasons by 2001.

Rudolstadt Thüringer Landesmuseum Heidecksburg zu Rudolstadt, beim Landkreis Saalfeld-Rudolstadt, Schloßbezirk 1, D-07407 Rudolstadt, Germany. Formerly Rudolstädter Naturhistorischen Museum. Curator: Dr Eberhard Mey. Founded 1757 by Prince Friedrich Carl von Schwarzburg-Rudolstadt; former curators Julius Speerschneider, Otto Schmiedeknecht, Gustav Kalbe, Gerhardt Jahn, Siegfried Kuss, Wilhelm Ennenbach (Möller 2000). Includes local colls. (Thüringen), but also from Palestine, E Asia, and (on loan) those of Emil Weiske from (e.g.) Hawaii, Australia, etc.

Ruse Natural History Museum (NHMRB), 8 Nish Str., Ruse, Bulgaria. tel #-359-82-444754, fax #-359-82-272397. Includes c.400 skins (150 species) from the Ruse region in NE Bulgaria, all on system cards.

Salzburg, Haus der Natur, Museumplatz 5, A-5020 Salzburg, Österreich/Austria. Tel. #-43-662-842653, fax –847905, e-mail office@hausdernatur.at. Head Prof Dr Eberhard Stüber, curator of vertebrate coll. Dr Robert Lindner (robert.lindner@hausdernatur.at). Founded in the 1930s; owned by private charity (Verein für darstellende und angewandte Naturkunde Haus der Natur). Former curator E. P. Tratz. Includes c.2,000 birds skins (e.g. from the coll. of V. Tschusi zu Schmidhoffen), hundreds of mounts (largely without proper labels), and a small but unknown number of skeletons, skulls, egg sets, nests, and feathers. The skins are mostly from Austria (esp. the Salzburg region), but the coll. includes birds also from S Germany, the Afrotropics, and C & S America

San Gimignano Museo Ornitologico di S. Gimignano, Siena prov., Italy. The former coll. of the Marchioness M. Paulucci, who had 1,260 mounted birds at her death in 1911, of which 696 (253 species) remain. See Massi (1990 & undated).

Sankt Gallen Naturmuseum Sankt Gallen, Museumstraße 32, CH-9000 Sankt Gallen, Switzerland. Tel. #-41-71-2420670, fax -2420672. Head: Dr Toni Bürgin (tbuergin@naturmuseumsg.ch). A small coll. of local and exotic birds, e.g. from Ussuriland (Russian Far East)

Saratov Zoological Museum of Saratov State University (ZMSSU), Astrakhanskaya, 83, Saratov 410026, Russia. Tel #-7-8452-519228, e-mail anikinvv@info.sgu.ru, yakushevnn@info.sgu.ru. Head of bird dept Gennady V. Shlyakhtin, coll. managers Vasili V. Anikin, Mikhail V. Ermokhin, Evgeny V. Zavyalov, also 4 other staff members; past staff members I. B. Volchanecky and L. A. Lebedeva. Specialised in the Volga-Ural region, but a large coll. was lost in fire; the present coll. of 1,900 bird skins was formed after 1991 and is registered on card and computer; c.200 species are represented. The average increase at present is 1,000 skins annually, from own expeditions.

Schlagl Schlagl Institut, Österreich. A small bird coll. See Petz (1984).

Sheffield Sheffield City Museum, Weston Park, S10 2TP Sheffield, U.K. Tel #-44-114-2782600. Keeper of Natural History: Derek Whiteley. Includes a small bird coll.: see D. Whiteley (1984) *Magpie* 3: 47-53.

Siracusa Liceo Classico 'T. Gargallo'. Hosts the Riza coll., originally of 2,700 mounts (of which only 330 survive). Former curator: Prof. G. Sturniolo. See Naturalista Siciliano 18: 297-299.

Southend-on-Sea Southend Central Museum (SOUMS), Victoria Avenue, Southend-on-Sea

SS2 6EW, Essex, U.K. Tel.: #-44-1702-215640, fax -215631. Senior Keeper of Natural History: John Skinner (john.skinner@bigfoot.com). Includes 30 skins, c.500 mounts (mainly from the colls. of C. Parsons and J. D. Hoy), and 300 egg sets, mostly of local origin (Essex); see Pollitt (c.1925).

Split Prirodoslovnog Muzeja, 58000 Split, Croatia. Curator Dr G. Piasevoli; contains 1,161 birds of 230 species: see *Larus* 43: 89-119.

Stettin see Szczetin

Stia Collezione ornitologica 'Carlo Beni', Stia, Arezzo prov., Italy. Includes c.500 mounts collected around 1900 in Tuscany. Is moving to the visitor centre of the Parco Nazionale Foreste Casentinesi. See G. Tellini Florenzano (1997).

Suceava Museum Departamental, Suceava, Romania. For the small bird coll., see M. Vasiliu, A. Ulsamer, D. Zaharia, & D. R. Maxim (1983) *Anuarul Muz. jud. Fasc. Stiint. Nat.* 7: 75-95

Swansea Swansea Museum, Victoria Road, Maritime Quarter, Swansea SA2 0JE, U.K. Tel.: #-44-1792-653763, fax –652585. Curator: Bernice Cardy. Founded 1834, owned by Swansea City Council. Includes c.200 mounts, a few skeletons, and 200 eggs sets, mostly British, e.g. of the colls. of John Naylor (1860) and W. G. Percy Player.

Sykkylven Sykkylven Naturhistorisk Museum , Kulturkontoret, N-6230 Sykkylven, Norway. Tel. #-47-7025-1500, fax –1501. Has a small bird coll.

Szczetin (Stettin) This Polish city once housed a museum which, among others, contained the coll. of its former founder and curator H. Dohrn, with birds of, e.g., the Cape Verde Is. After 1945 this coll. was transferred to Warszawa, but many of the Dohrn specimens seem to have been lost. See Hazevoet (1995).

Tallinn Eesti Loodusmuuseum/ Estonian Museum of Natural History, Lai tn. 29A, Tallinn 10133, Estonia (work address of zoology dept.: Kopli tn. 76, 10416 Tallinn). Tel. #-372-6-411738, e-mail museum@online.ee. The bird coll. includes material of V. Russow, A. Rauch, and P. Wasmuth.

Tbilisi Zoological Institute (ZIT), Georgian Academy of Sciences, 31 Chavchavadze pr., 380030 Tbilisi, Georgia. Founded by G. Radde, now part of the Georgian Academy of Sciences. Includes the large coll. of G. Radde and others, mainly from the Caucasus area, Crimea, NE Turkey, Soviet Far East, etc. The Tbilisi coll. was in poor condition in c.1985, when it was stored undergroud.

Tessenderlo Bosmuseum Gerhagen, Zavelberg 10, B-3980 Tessenderlo, Belgium. Tel & fax #-32-13-3673844/ -3663448, e-mail bosmuseum@village.uunet.be. Contact: Jos Thijs. Founded 1968 as part of the Werkgroep Ecologie Tessenderlo (WET), a volunteer association (secretary: Herman Vermeulen, hvermeulen@skynet.be). Includes a coll. of c.330 mounted birds, mostly local and recently acquired.

Thessaloniki Zoological Museum (LZUT), University of Thessaloniki, Thessaloniki, Greece. Director: Dr Elena Voultsidou-Koukoura. Includes a small bird coll.

Timisoara A museum in this W Romanian city has a small bird coll. Curator: D. Lintia

Torino see Turin

Tournai Musée d'Histoire Naturelle et Vivarium, Cour d'Honneur de l'Hôtel de Ville, B-7500 Tournai (Doornik), Belgium. Tel. #-32-69-322345, fax –233939, e-mail mushn@swing.be. Conservateur Dr Philippe Brunin, conservateur-adjoint Christophe Remy; former curator Paul Simon. Founded 1828, with most acquisitions before 1860. Of the 4,700 bird skins and mounts only 1,000–2,000 have proper labels; the other original labels were inadvertently thrown away in the 1960s. The coll. includes a small number of skeletons (c.20) and eggs (c.30).

Trieste Museo Civico do Storia Naturale (MSNT), Piazza Hortis 2, I-34123 Trieste, Italy. A small bird coll., which includes some exotic ones. A catalogue of all birds is available.

Tübingen Zoologische Sammlung der Universität Tübingen (ZST), Tübingen, Germany. Curator: Dr Erich Weber (Erich.Weber@uni-tuebingen.de; tel. #-49-7071-29-4634). A coll. founded c.1841 and now part of the Zoologisches Institut der Eberhard-Karls-Universität Tübingen. Includes about 2,000 bird skins and mounts, 1,300 (partial) skeletons, 500 egg sets, and a small feather coll., to which 20–50 items are added annually (mainly feather sets and skeletons);

includes part of the coll. of Herzog Paul von Württemberg. All items on card, newer ones on computer.

Turin/Torino The Collegio San Giuseppe in Turin (CSGT) includes a large coll. of c.1000 mounted hummingbirds, totalling 226 species, brought together by Pietro Franchetti (1878–1964). See Aimassi & Levi (1999) for a catalogue.

Turku Zoological Museum (MZT), Centre for Biodiversity, University of Turku, FIN-20014 Turku, Finland. Contact person: Ari Karhilahti (taxidermist) (arikar@utu.fi). Past curator P. Voipio; incl. a skin coll. from K. S. Ehnberg. The MZT has 1,726 skins, 700 mounts, 1,000–1,500 egg sets, 160 spread wings, and fewer than 100 skeletons and birds in alcohol, all largely from Finland, to which 50–150 birds are added annually. All are on computer. For a catalogue, see www.utu.fi/ML/biologia/elainmuseo.

Turnhout Natuurhistorisch Museum van Natuurvereniging De Wielewaal, Graatakker 11, B-2300 Turnhout, Belgium. Includes a small coll. of mounted birds

Udine Museo Friuliano di Storia Naturale, Via Grazzano 1, I-33100 Udine, Italy. Has a small bird coll., curated by a taxidermist. Skin catalogue available. For the egg catalogue, see: R. Parodi *et al.* (1988) *Mus. Friulano Stor. Nat. Pubbl.* 34: 1-30.

Varna Museum of Natural History (MNHV), P.O. Box 173, 9000 Varna, Bulgaria. Tel #-359-52-601891, fax #-359-52-681025. Curator: Georgi Raychev, former curator Ivan Peshev. Founded 1960, owned by Municipality of Varna. Contains 350 bird skins of c.140 species, all on card; c.20 added annually, mainly birds from the Varna area (NE Bulgaria).

Vercelli (Italy) Includes a small coll. of 580 mounted birds, made by Mr. Ferrero (see *Suppl. Ric. Biol. Selvaggina* 22, 1995).

Vienna/Wien The Vienna University has a small bird coll., which for instance includes 2 *Heteralocha acutirostris.*

Winterthur Naturwissenschaftliche Sammlungen Stadt Winterthur, Museumstraße 52, CH-8400 Winterthur, Switzerland. Tel. #-41-52-2675166, fax –2675319. Includes a small coll. of local birds.

Witney Oxfordshire County Council Museums, Oxfordshire Museums Store, Cotswold Dene, Standlake, Witney, Oxon OX29 7QG, U.K. Tel.: #-44-1865-300639, fax –300519. Curator of Biological Records Centre: John Campbell (john.campbell@ oxfordshire.gov.uk). From Aug 2000, includes the egg coll. of the Jourdain Society, which started from 1964 with the donations of older colls. of deceased members. The most important contributors were K. J. Pickford, C. J. Pring, J. W. Mullholland, and S. A. R. Smith (but not F. C. R. Jourdain himself: his egg coll. is in Tring). Has 12,000 egg sets, mostly on card, 5,000 on computer, from the entire W Palearctic. The museum store also includes a coll. of over 300 eggs of Theed Pearce, donated by Bruce Campbell.

Yerevan Zoological Institute (ZIA), Armenian Academy of Sciences, Yerevan, Armenia. Has a bird coll. of unknown size.

York Yorkshire Museum, Museum Gardens, York, North Yorkshire YO1 7ER, U.K. Tel.: #-44-1904-629745, fax –651221. Asst. Curator of Natural Science: Stuart Ogilvy. Contains 3,073 bird skins and c.2,000 eggs (Denton 1995).

Please note the addresses of 2 other institutions interested in zoological/ ornithological collections:

(1) the ornithological collections survey of the International Ornithological Committee, c/o Walter J. Bock, Dept. of Biological Sciences, Box 37, Schermerhorn Hall, Columbia University, New York NY 10027, USA;

(2) the ESF Network of Systematic Biology, secretary Ms Nicola Donlon, The Natural History Museum, Cromwell Road, London SW7 5DB, U.K.

Not listed above but not unimportant are the collections specialising in vocalisations of birds:

(1) National Sound Archive of the British Library (Curator of Wildlife Sounds: Richard Ranft), 96 Euston Road, London NW1 2DB, U.K. (tel #-44-171-4127402, e-mail richard.ranft@bl.uk);

(2) The Boris N. Veprintsev Phonotheca of Animal Voices (Olga D. Veprintseva, V. V. Leonovich, S. A. Boukreev), Inst. of Theoretical and Experimental Biophysics of Russia, Academy of Sciences, 142292 Pushchino, Russia. See Veprintseva (1999).

Many other museum collections also contain bird sound libraries.

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This list largely originated from data supplied by the curators of the various collections mentioned. They receive my most sincere thanks, especially those who also provided data on collections from which no response was received or who supplied literature on these. I hope that these combined efforts will benefit all and will lead to a better use of European bird collections and an increasing mutual cooperation of their staff and students. Many additional data and comments were received from Jörn Scharlemann and Frank Steinheimer during the final stages of this paper.

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These are mainly on the history, catalogues, or type lists of European bird collections, as supplied by respondents to the questionnaires. The data were in part supplied incompletely, but no attempt has been made to improve them, nor were the texts of the referred articles checked to see whether the questionnaires were filled in correctly. This is not a complete list of all existing literature on type catalogues; for a more full list of these, see Wiktor & Rydzewski (1991) below. Literature cited in the introduction and elsewhere is given here also.

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Appendix 1

European museums by country. Countries are listed alphabetically, but museums within countries are listed in order of the number of specimens they possess. The third column indicates which list the museum is treated under.

Country	City	List
Armenia	Yerevan	B
Austria	Vienna/Wien (NMW)	A
	Linz	A
	Salzburg	B
	Graz	B
	Innsbruck	B
	Schlagl	B
	Vienna/Wien (Univ)	B
Belgium	Tervuren	A
	Brussels/Bruxelles	A
	Tournai	B
	Heusden-Zolder	B
	Turnhout	B
	Tessenderlo	B
Bosnia	Sarajevo	A
Bulgaria	Sofia	A
	Pleven	B
	Plovdiv	B
	Burgas	B
	Ruse	B
	Varna	B
	Dobrich	B
	Panagyurishte	B
Croatia	Zagreb	A
	Split	B
Czech Rep.	Prague/Praha	A
	Prerov	A
	Brno	A
	Olomouc	B
	Opava	B
	Budisov	B
	Plzen	B
	Hradec Kralove	B
	Bitov	B
	Novy Jicin	B
	Çeska Lipa	B
Denmark	Copenhagen/København	A
	Århus	B
Estonia	Tartu	A
	Tallinn	B
Finland	Helsinki	A
	Turku	B
France	Paris	A
	Nantes	A
	Strasbourg	A
	Toulouse	A
	Lille	A
	Grenoble	A
	Nancy	B
	Montauban	B
	Le Havre	B
	Monaco	B
	Dijon	B
	Lyon	B
	Rouen	B
	La Rochelle	B
	Autun	B
	Bordeaux	B
	Marseille	B
	Nice	B
	Perpignan	B
	Rennes	B
Georgia	Tiflis/Tbilisi	B
Germany	Berlin	A
	Bonn	A
	Frankfurt a/M	A
	Stuttgart	A
	Dresden	A
	Munich/München	A
	Hamburg	A
	Kiel	A
	Braunschweig	A
	Bremen	A
	Halberstadt	A
	Halle	A
	Coburg	A

	Hanover/Hannover	A
	Wiesbaden	A
	Leipzig	A
	Görlitz	A
	Wilhelmshaven	A
	Magdeburg	A
	Münster	A
	Karlsruhe	A
	Mainz	B
	Altenburg	A
	Tübingen	B
	Göttingen	B
	Bamberg	B
	Bad Durkheim	B
	Rostock	B
	Greifswald	B
	Darmstadt	B
	Köthen	B
	Rudolstadt	B
	Augsburg	B
	Bielefeld	B
	Chemnitz	B
	Dortmund	B
	Erlangen	B
	Hildesheim	B
	Kassel	B
	Lübeck	B
	Regensburg	B
Greece	Athens/Athinai	A
	Thessaloniki	B
Hungary	Budapest	A
	Pécs	B
Iceland	Reykjavik	A
	Akureyri	B
Ireland	Dublin	B
Italy	Milan/Milano	A
	Genoa/Genova	A
	Turin/Torino (MRSN)	A
	Florence/Firenze	A
	Rome/Roma	A
	Pisa	A
	Bologna (INFS)	A
	Terrasini	A
	Verona	A
	Pavia	B
	Forli	B
	Venice/Venezia	A
	Siena	A
	Randazzo	B
	Naples/Napoli	B
	Ravenna	B
	Ferrara	B
	Livorno	B
	Casalnuovo Monterotaro	B
	Bologna (MZUB)	B
	Turin/Torino (CSGT)	B
	Padua/Padova	B
	San Gimignano	B
	Rimini	B
	Vercelli	B
	Stia (Arezzo)	B
	Fermo	B
	Siracusa	B
	Bari	B
	Brescia	B
	Cagliari (Sardinia)	B
	Catania	B
	Chieri	B
	Trieste	B
	Udine	B
Lithuania	Kaunas	A
Luxemburg	Luxembourg	B
Netherlands	Leiden	A
	Amsterdam	A
	Rotterdam	A
	Leeuwarden	B
	Maastricht	B
Norway	Oslo	A
	Bergen	A
	Tromsö	A
	Stavanger	A
	Trondheim	A
	Elverum	B
	Kristiansand	B
	Sykkylven	B
Poland	Warsaw/Warszawa	A
	Wroclaw	A
	Krakow	A
	Jelenia Góra	B
	Bialywieza	B
	Bytom	B
	Czestochowa	B

	Szczecin/Stettin	B
Portugal	Lisbon/Lisboa (CZ/IICT)	A
	Coimbra	A
	Lisbon/Lisboa (MB)	A
	Porto	B
	Funchal (Madeira)	B
	Cruz Quebrada	B
	Ponta Delgada (Azores)	B
Romania	Bucharest	A
	Sibiu	A
	Reghin	B
	Bacau	B
	Oradea	B
	Cluj-Napoca	B
	Suceava	B
	Timisoara	B
Russia	St Petersburg (ZISP)	A
	Moscow (ZMMU)	A
	Moscow (SDM)	A
	St Petersburg (ZM/SPBU)	A
	Moscow (PIN/RAS)	A
	Moscow (MPSU)	B
	Moscow (Stepanyan)	B
	Saratov	B
	Moscow (Fac Geogr MGU)	B
	Moscow (Fac Biol MGU)	B
Slovakia	Bardejov	A
	Kosice	B
	Bratislava	B
Slovenia	Ljubljana	B
Spain	Madrid	A
	Seville/Sevilla	A
	Barcelona	A
Sweden	Stockholm	A
	Gothenburg/Göteborg	A
	Lund	A
	Uppsala	A
	Jönköping	B
	Malmö	B
	Härnösand	B
	Jokkmokk	B
Switzerland	Genève	A
	Basel	A
	Bern	A
	Neuchatel	A
	Lausanne	A
	Fribourg	A
	Zürich	A
	Winterthur	B
	Sankt Gallen	B
Tatarstan	Kazan	B
U.K.	Tring	A
	Edinburgh	A
	Liverpool	A
	Cambridge	A
	Cardiff	A
	Brighton	A
	Manchester	A
	Newcastle	A
	Oxford	A
	Sevenoaks	A
	Witney	B
	Bolton	A
	Bristol	A
	Exeter	A
	Glasgow	A
	Leeds	A
	Carlisle	B
	Birmingham	B
	York	B
	Saffron Walden	B
	Coventry	B
	Ludlow	B
	Birchington	B
	Southend-on-Sea	B
	London (Grant Mus.)	B
	London (Surgeons Coll.)	B
	Swansea	B
	Kendal	B
	Norwich	B
	Nottingham	B
	Leicester	B
	Sheffield	B
Ukraine	Kiev	A
	Lviv	A
	Melitopol	B
	Odessa	B
Yugoslavia	Belgrade/Beograd	A
	Novi Sad	B
	Pristina	B

Appendix 2

Index of persons named in the lists above, with museums where collections of these persons are housed (if they had any). (*) denotes persons at present active in the museum mentioned

Abbot, J. (Liverpool); Abel (Bremen); Absolon, Karel (Brno); Acerbi, C. (Padova); Achtelig, Michael (Augsburg)*; Adams, Jeremy M. (Brighton)*; Adams, Leith (Edinburgh, Tring); Adams, Mark (Tring)*; Adelborg (Stockholm); Agassiz, Louis (Neuchâtel); Aguilar-Amat (Barcelona); Aimassi, G. (Chieri); Aitchison, James (Tring); Ajola (Terrasini); Alexander, Boyd (Tring); Alleon, Amedé (Sofia); Almaça, Carlos (Lisboa-MB)*; Almásy von Zsadány und Törökszent, George Graf (Budapest, München, Wien); Altner, H.-J. (Halle)*; Altobelli, Anna (Firenze)*; Altobello, G. (Bologna INFS, Bologna MZUB); Altum, Bernhard (Münster); Anchieta (Bremen); Andersen (Elverum)*; Andersen, Knut (Sofia); Andersen, Th. (Basel, Bonn, Bremen, Karlsruhe, København, Leiden, München, Stuttgart); Anderson, J. G. (Bremen, Stockholm); Anderson, John (Tring); Andersson, Carl J. (Stockholm); Andreevsky, V. (St Petersburg ZM SPBU); Andrew, Katherine (Ludlow)*; Angele, Theodor (Linz); Anhalt-Köthen, August Herzog von (Köthen); Anikin, Vasili V. (Saratov)*; Ansorge, Hermann (Görlitz)*; Ansorge, W. J. (Tervuren); Antinori, Orazio Marquis (Genova, Roma, Torino); Aosta, Elena Duchess of (Napoli); Aplin, Oliver V. (Oxford); Arbuthnot, Robert (Glasgow); Arcamone, E. (Livorno); Armstrong, F. B. (Tring); Arnone, Marcello (Terrasini); Arrigoni degli Oddi, Count Ettore (Roma); Arthur, Ms Jane (Birmingham)*; Ashmole, Elias (Oxford); Askew, Capt. (Cambridge); Askeyev, Oleg V. (Kazan)*; Aubrecht, Gerhard (Linz)*; Austria, Franz II, Emperor of (Wien); Ayres, Thomas (Bremen, Liverpool);

Babault, Guy (Paris); Baccetti, Baccio (Siena)*; Baccetti, Nicola (Bologna INFS, Siena)*; Bäckstrom, K. (Stockholm); Baddeley, M. O. E. (Bonn); Bährmann, Udo (Dresden); Bailly (Grenoble); Bairlein, Franz (Wilhelmshaven)*; Balat, Frantisek (Brno); Baldamus, W. (Coburg); Baldassarri, G. (Siena); Baldi, A. (Budapest); Balfour (Bremen); Balthasar, Vladimír (Hradec Králové); Bamberg, Otto (Amsterdam, Bonn, Stockholm); Banaduc, Doru (Sibiu)*; Bangert, C. (Stockholm); Bankovics, Attila (Budapest)*; Banks, Joseph (see Mus. Leverianum); Bannerman, David A. (Tring); Barbagli, Fausto (Firenze)*; Barboza du Bocage, José V. (Lisboa-MB); Barej, Thomas (Warszawa); Barentsz Exped. (W. Bierman, H. van der Lee) (Amsterdam); Barnett, Ray (Bristol)*; Baron, Oskar T. (Frankfurt); Barreiro, Josefina (Madrid)*; Barrett, Robert (Tromsö)*; Barrow, Sir John (Oxford); Bart, André (Lille); Bartels Sr., Max E. G. (Braunschweig, Leiden); Barth, C. von (Stuttgart); Barth, Edvard K. (Oslo); Basanovic, Ms (Pristina); Bates, George L. (Liverpool, Tervuren, Tring); Bates, Paul (Sevenoaks)*; Baud, François J. (Genève)*; Baudin, Nicolas (Paris); Bauer, Ferdinand L. (Wien); Bauer, Kurt M. (Wien); Bauernfeind, Ernst (Wien)*; Baxter, Evelyn V. (Edinburgh); Bayern, Maximilian III König von (München); Bayern, Prinzessin Therese von (München); Beale, Charles (Birmingham); Beaufort, Lieven F. de (Amsterdam); Beavan, Robert C. (Tring); Beccari, Odoardo (Genova, Milano, Torino); Bechet, George (Luxembourg)*; Becker, Peter R. (Bielefeld*, Bremen); Beczy, Toma L. (Oradea); Beddall-Smith (Coventry); Beeyner, Nelo (Coimbra); Behn, Friedrich (Frankfurt); Behn, Wilhelm F.G. (Kiel); Beick, Walter (Berlin, København); Bellgrove (Coventry); Bengtson, Sven-Axel (Lund)*; Benson, Constantine W. (Cambridge); Bentz, Per-Göran (Malmö)*; Beretzk, Peter (Budapest); Berezowskii, M. M. (St Petersburg ZISP); Berg, Bengt (Dresden); Berg, Günther H. D. Freiherr von (Strasbourg); Berg, Hans-Martin (Wien)*; Berger (Strasbourg); Berger, Arthur (Berlin); Bergman, Göran (Helsinki); Bergman, Sten (Stockholm); Berlepsch, Hans H. C. L. Graf von (Frankfurt); Berlin, A. (Jönköping); Berlioz, Jacques (Paris); Bernier, Chevalier J.A. (Paris); Bernis, Francisco (Madrid); Bernoft-Osa, Anders (Oslo, Stavanger); Bernoulli, Hieronymus (Basel); Bernstein, Heinrich A. (Leiden); Berry, Kathryn (Bolton)*; Besaucèle, V. (Toulouse); Bessi (Firenze); Betteridge (Coventry); Bewick, Thomas (Newcastle); Bianki (Bianchi), Valentin L'vovich (St Petersburg ZISP, St Petersburg ZM SPBU); Biddulph, John (Tring); Bielewicz, M. (Bytom); Bielz, Eduard A. (Sibiu); Bierman, Willem H. (Amsterdam); Bilkevich, S. I. (St Petersburg ZM/SPBU); Binder, Jon. Fr. & Franz (Sibiu); Bingham, C. T. (Tring); Bisacco Palazzi, Giacomo (Venezia); Black, M. A. (Glasgow); Blackie, Churchill (Exeter); Blanc, M. (Amsterdam, Roma); Blanchet, A. (Grenoble); Blandin (Nantes); Blanford, William (Tring); Blasius, Johann H. (Braunschweig); Blasius, Wilhelm (Braunschweig); Blewitt, W. T. (Tring); Blezard, E. (Carlisle); Blumenbach, Johann F. (Göttingen); Blyth, Edward (Cambridge); Bochenski, Zbigniew

(Krakow)*; Bochenski, Zygmunt (Krakow)*; Bock, Carl (Tring); Boenigk, Gerhard (Braunschweig)*; Boetsscher, Hermann (Görlitz); Boetticher, Hans von (Coburg, Frankfurt, Halberstadt, Halle, Sofia); Boev, Nikolay (Sofia NMNHS); Boev, Zlatozar (Sofia NMNHS)*; Bogdanov, Modest Nikolaevich (Moscow ZMMU, St Petersburg ZM SPBU); Böhm, Richard (Berlin); Boie, F. (Kiel); Boie, Heinrich (Leiden); Bojer, Wenzel (Wien); Bokotei, A. A. (L'vov); Bolau, Heinrich & Hermann (Hamburg); Bolton, David (Exeter)*; Bon, Mauro (Venezia)*; Bondesen, Paul (Århus); Bonelli, Franco A. (Torino); Bonjour (Nantes); Bonnevie (Tervuren); Bonsdorff, E. J. (Helsinki); Bonvalot, G. (Paris); Booth, Edward Thomas (Brighton); Borelli, A. (Torino); Borivoje, Zuza (Sarajevo)*; Borrer, William (Brighton); Bostanzhoglo, V. N. (Moscow ZMMU); Bottego, V. (Genova); Boucard, Adolphe (Madrid, Paris, Stuttgart); Bourcier, Jules (Paris); Bourret, R. (Toulouse); Bouteille (Grenoble); Bouvier, Maison (Berlin, Milano, Paris); Bovallius, Dr (Stockholm); Bracker-Braun, Cordula (Hamburg)*; Brandolini, Alfredo (Ravenna); Brandt, Johann F. von (St Petersburg ZISP); Brandt, Johann G. W. (Halberstadt, Halle); Brandt, T. T. (St Petersburg ZISP); Branicki, Alexander, Konstantin, & Xaver Graf von (Warszawa); Braun, Horst (Bremen)*; Braunschweig und Lüneburg, Herzog Carl I von (Braunschweig); Braybrook, Lord Richard G. (Saffron Walden, Essex); Bregulla, Heinrich (Bonn) ; Brehm, Alfred E. (Bonn, Braunschweig, Bremen, Halle); Brehm, Christian L. (Altenburg, Bonn, Braunschweig, Coburg, Wien); Brendel (Halle); Brichetti, Pierandrea (Brescia)*; Bridges, T. (Liverpool); Brisson, Mathruin-Jacques (Paris); Brogi, Sigismondo (Siena); Brooke, Michael de L. (Cambridge)*; Brooks, W. E. (Liverpool, Tring); Brown, Henry (Glasgow) ; Brüggemann, Friedrich G.F. (Darmstadt, Dresden, Tring); Brühl, L. (Halle); Bruijn, A. A. (Leiden, Milano, Paris, Torino, Wiesbaden); Brunin, Philippe (Tournai); Bryant, Henry (Bremen); Bub, Hans (Wilhelmshaven); Buch, Père A. (Fribourg); Buchanan, Angus (Tring); Büchi, Othmar (Fribourg); Buchner, E. (St Petersburg ZM SPBU); Buckley, T. E. (Cambridge); Buda, Adam & Alexius (Sibiu); Buffon, George-Louis Leclerc, Comte de (Paris); Bulgaria, Boris III of (Sofia); Bulger, Capt. (Bremen); Buller, R. Hughes (Exeter); Buller, Walter (Liverpool, Tring); Bullock, William/Mus Leverianum (Berlin, Edinburgh, Leiden, Liverpool, Paris, Torino, Wien); Burchell, William J. (Oxford); Bureau, Louis (Nantes); Buresch, Ivan (Sofia); Burg, Gustav von (Roma); Bürger, Hermann (Leiden); Burger, O. (Dresden); Bürgers, Joseph (Berlin); Bürgin, Toni (Sankt Gallen)*; Burke, J. (Liverpool); Burmeister, Karl Hermann C. (Halle); Busch, Rudolf (Halberstadt); Büsching, W.-D. (Köthen); Butiev, Vladimir T. (Moscow MPSU)*; Butler, Arthur L. (Tring); Butler, Edward A. (Tring); Büttikofer, Johann (Leiden); Buturlin, Sergei Aleksandrovich (Moscow ZMMU); Buturovic, Denana (Sarajevo)*; Bybartas, K. (Kaunas); Bykov (St Petersburg ZISP); Byrkjedal, Ingvar (Bergen)*;

Cabanis, Jean L. (Berlin, Halberstadt); Cabot Nieves, José (Sevilla)*; Cagnolaro, Luigi (Milano)*; Caley, G. (Tring); Campbell, Bruce (Witney); Campbell, J. M. (Glasgow); Campbell, John (Witney)*; Cancelli, Fabrizio (Siena)*; Canesi (München); Capek, Vaclav (Brno); Cardy, Bernice (Swansea)*; Carlini, R (Roma)*; Carlos III, King of Spain (Madrid); Carlsson, Von (Stockholm); Carpine, C. (Monaco); Carraro (Verona); Carreira, Isabel M.G. (Coimbra)*; Carruccio, A. (Roma); Carruthers, Alexander Douglas M. (Tring); Carvalho, Luis de (Coimbra); Casellato, Sandra (Padova)*; Castroviejo, J. (Sevilla); Cederholm, Lennart (Lund); Chambers, W. T. H. (Exeter); Chapin, James P. (Tervuren); Chapman, Frank M. (Bremen); Charon (Nancy); Chase, Robert W. (Birmingham); Chatterjee, Helen (London Univ. Coll.)*; Cheesman, Robert E. (Tring); Chen, K. H. (Leiden); Cherrie, George (Frankfurt); Cherubini, Giuseppe (Venezia)*; Chevalier (Stuttgart); Chigi della Rovere, F. (Roma); Chill, W. N. (Tring); Chiozzi, Giorgio (Milano)*; Chorinsky, Friedrich (Brno); Christie, Major (Glasgow) ; Christison, A. F. Philip (Tring); Christy, C. (Tervuren); Chrostowski, T. (Warszawa); Cignini, B. (Roma); Cikovic, Davor (Zagreb)*; Cipolla (Verona); Clancey, Philip A. (Amsterdam, Bonn, Edinburgh); Clark, A. S. (Edinburgh); Clark, William Eagle (Edinburgh); Clarke, Joseph & Joshua (Saffron Walden, Essex); Clary, M. (Lyon)*; Clement, Morag (Kendal)*; Clot-Bey, Antoine B. (Grenoble); Cochrane, Capt. H. L. (Glasgow) ; Cockburn, Miss (Tring); Cockerell, James (Tring); Coles, A. (Newcastle)*; Collett, Robert (Oslo, Roma); Colston, Peter (Tring); Condé, Bruno (Nancy)*; Conrad, Capt. Paul (Bremen, Tring); Constancia, J. S. (Cambridge); Cook, James (see Mus. Leverianum); Coomans de Ruiter, Louis (Leiden); Cooper, Jo (Tring)*; Cossaune, G. (Toulouse); Costa, Achille (Napoli); Coulon, Louis (Neuchâtel); Cowan, W. D. (Liverpool, Tring); Coward (Manchester); Coxen, Charles & S. (Tring); Crabbe, Major Bingham (Brighton); Crampton, W. T. (Leeds); Crawford-Cabral, João (Lisboa-CZ/IICT); Cretzschmar, Philipp J. (Frankfurt); Cripps, J. N. (Tring); Crnkovic, R. (Zagreb); Cross, Capt. Donald (Glasgow); Crowley, Philip (Tring); Cruz, Teodoro J. (Coimbra); Csorba, G. (Budapest);

Csörgey, Titus (Budapest); Csörgö, Tibor (Budapest)*; Cuénot, L. (Nancy); Cuming, Hugh (Liverpool, Tring); Cumming, Walter (Exeter, Tring); Cunha, Maria José (Porto)*; Cursham, C. W. (Dresden); Curtis-Edwards, L. A. (Brighton); Cuvier, Frédéric (Paris); Czekelius sen., D. (Sibiu);

D'Urban, William S. M. (Exeter); Dainelli (Firenze); Dal Fiume, Camillo (Verona); Dal Nero, Vittorio (Roma, Verona); D'Albertis, Luigi M. (Genova, Milano, Torino); Dalgleish, James G. (Brighton); Dalmas, Comte R. de (München); Dalous, Pierre (Toulouse)*; Dam, D. C. van (Leiden); Darwin, Charles R. (Tring); David, Père Armand (Paris); David-Beaulieu, A. (Paris); Davis, Barry (London RCSE)*; Davison, C. (Tring); Davison, William R. (Liverpool, Tring); Day, Francis (Cambridge); De Betta (Verona); De Boccard, Raymond (Fribourg); De Buman, Charles & Joseph (Fribourg); De Bussy, Louis P. le Cosquino (Amsterdam) ; De Cristoforis, Giuseppe (Milano); De Faveri, Adriano (Bologna INFS)*; De Filippo, G. (Napoli); De Mons, Count Br. (Wiesbaden); De Romita (Bari); De Roo, A. (Tervuren); De Selys-Longchamps (Brussels); De Witte, G. F. (Tervuren); De Wylder, G. (Stockholm); Decken, Karl Claus Freiherr Von der (Berlin); Degland, Cômte Damien (Lille); Dei, Apelle (Siena); Dekker, René W. R. J. (Leiden)*; Delacour, Jean (Paris, Tring); Delalande, Pierre A. (Paris); Delibes, M. (Sevilla); Dementiev, Georgii Petrovich (Moscow SDM, Moscow ZMMU); Dementiev, Maksim N. (Moscow – Biol. Fac. MGU)*; Demidov, P. G. (Moscow ZMMU); Deniger, K. (München); Denton (Yorkshire); Deppe, Ferdinand (Wien, Berlin); Derby, Earl of: see Lord Stanley (Liverpool); Derjugin, K. (St Petersburg ZM SPBU); Dernedde, Karl (Bonn); Desfayes, Michel (Neuchâtel); Detharding, Georg G. (Rostock); Devillers, Pierre (Brussels); Diard, Pierre M. (Leiden, Paris, Tring); Diesener, Ruth (München)*; Diesselhorst, Gerd (München); Dietrich, Amalie (Bamberg, Bremen, Hamburg); Dimitrov, Velik (Pleven); Dinesen, G. B. (Amsterdam, Roma); Dingemans-Bakels, F. N. (Maastricht)*; Döbel (Frankfurt); Döderlein, Ludwig H. P. (Strasbourg); Doflein, Franz J. T. (München); Dohrn, Heinrich (Bremen, Frankfurt, Szczetin); Domaniewski, Janusz (Warszawa); Dombrowski, Robert Ritter von (Amsterdam, Bucharest, Wien) ; Domeier, Hans (Hannover); Domènech (Barcelona); Donchev, Stefan (Sofia); Doria, G. (Genova)*; Doria, Marquis Giacomo (Genova, Torino); Dörries, Friedrich C.G. (Braunschweig, Hamburg, Tring); Dorst, Jean (Paris); Dovic, Janez (Ljubljana); Down, Rozina (London Univ. Coll.); Drescher, E. (Bytom); Dresser, Henry E. (Manchester); Dreyer, Wolfgang (Kiel)*; Drost, Rudolf (Wilhelmshaven); Droste-Hülshoff, Ferdinand Freiherr von (Münster); Du Bus de Ghisignies, V. Bernard L. (Brussels); Du Chaillu (Bremen); Du Petit-Thouars, Abel A. (Paris); Dubois (Le Havre); Dufresne, L. (Edinburgh, Paris); Dumont d'Urville, Jules S.C. Vicomte (Paris); Dunajewski, Andreas (Warszawa); Duncker, Hans (Bremen); Dunlop, E. B. (Carlisle); Duoc (Stuttgart); Duperrey, L. (Paris); Dupond, Charles (Brussels); Dupont, Maison (Paris); Dürck, H. (München); Durnford, Henry (Tring); Dutton, T. P. (Edinburgh); Duvaucel, Alfred (Paris); Duve (Stuttgart); Dybowski, Benedikt I. (Warszawa, Lviv); Dzerzhinski, Felix Ya. (Moscow – Biol. Fac. MGU)*;

Earl of Derby (Liverpool); Eck, Siegfried (Dresden)*; Eckloff, Wolfgang (Lübeck)*; Edelstam, Carl (Stockholm)*; Edinburg Univ. Museum (Edinburgh); Edwards, W. H. (Birmingham); Ehlers (Göttingen); Ehnberg, K. S. (Turku); Ehrenberg, Christian G. (Berlin, Wien); Eisenhofer (Stockholm); Eisentraut, Martin (Bonn); Elliot, Daniel G. (Stuttgart); Elliot, Major-General (Exeter); Ellis, Willoughby (Birmingham); Elpatev, V. S. (St Petersburg ZISP); Emin Bey: see Emin Pasha; Emin Pasha/Pascha (= Eduard Schnitzer, Arthur Schnitzler) (Berlin, Bremen, Milano, Tring, Wien); Engel, E. (Luxembourg)*; Engelbach, Pierre (Paris); Ennenbach, Wilhelm (Rudolstadt); Erard, Christian (Paris)*; Erckel, Theodor (Frankfurt); Ericson, Per (Stockholm)*; Erikkson, A. W. (Uppsala); Erikkson, Mats (Uppsala)*; Eriks, Arie (Amsterdam); Erlanger, Carlo Freiherr von (Frankfurt); Ermokhin, Mikhail V. (Saratov)*; Erthal, Franz Ludwig von (Bamberg); Escalera, de la (Barcelona); Etchécopar, Robert D. (Paris); Euler, Carl (Berlin); Everett, Alfred H. (Tring); Eversmann, E. A. (Kazan, St Petersburg ZISP); Eversmann, Eduard F. (Berlin, Kazan); Exped. Filchner (München); Exped. Pacifico 1862–1866 (Madrid); Exped. Stötzner (Dresden); Eykman, C. (Rotterdam); Eyres (Leeds);

Faber, Friedrich von (Berlin, Dresden, Leiden); Fadeev, Igor V. (Moscow SDM)*; Falk, Johann P. (St Petersburg ZISP); Farafontov, A. P. (Dresden); Farr, W. B. (Cambridge); Farren (Roma); Fasel, André (Fribourg)*; Fatio, Victor (Genève); Fayard, Armand (Grenoble)*; Fea, Leonardo (Genova, Torino); Feilden, Henry W. (Cambridge, Tring); Feldegg, Christoph Freiherr von (Praha); Feldmann, Carl (Wiesbaden); Ferrant, Victor (Luxembourg); Ferreira, Ms M. E. (Bonn); Festa, Enrico (Torino); Fetzer, Christian (Wiesbaden); Fiebig, Jürgen (Berlin); Filchagov, A. V. (Moscow Severtz. Inst.)*;

Filippi, Filippo De (Torino); Finsch, F. H. Otto (Berlin, Braunschweig, Bremen, Leiden, Wien); Firsova, L. V. (St Petersburg ZISP)*; Fischer von Waldheim, Johann G. (Moscow ZMMU); Fischer, Anton (Bonn, München, Stuttgart, Wiesbaden); Fischer, Georg (Bamberg); Fischer, Gustav A. (Berlin, Hamburg); Fisher, Clemency T. (Liverpool)*; Fitzgerald (Bremen); Fjeldså, Jon (København)*; Fleurian (Grenoble); Flint, Vladimir E. (Moscow ZMMU); Floericke, Curt (Bonn, Budapest, Sarajevo); Flükiger, Ernst (Bonn, Sevenoaks); Focke, Eberhard (Bremen, Hamburg); Fokkema, Johannes (Leeuwarden)*; Fomin, V. E. (Moscow ZMMU); Fontaine, Charles-Aloyse (Fribourg); Forbes, Henry O. (Liverpool, Tring); Forbes-Watson, Alec (Tring); Forsten, Eltio A. (Leiden); Forster, Johann George (see Mus. Leverianum); Forster, Johann Reinhold (Halle, and see Mus. Leverianum); Forsyth, Douglas (Tring); Forthuber, Michaela (Braunschweig)*; Foschi, F. (Forli, Roma); Foschi, U. F. (Forli)*; Frade, F. (Lisboa-CZ/IICT); Frahnert, Sylke (Berlin)*; Fraissinet, M. (Napoli); Franchetti, Pietro (Torino CSGT; Franco Dávila, Pedro (Madrid); Franeker, Jan-Andries van (Amsterdam); Frank, G. A. (Amsterdam, Dresden, Halberstadt, Halle, Strasbourg, Stuttgart, Leiden); Franzisket, Ludwig (Münster); Fraser, Louis (Liverpool, Tring); Freycinet, Louis C. D. de (Paris); Freyreiß, George W. (Berlin, Frankfurt, Leiden, Stockholm, Uppsala, Wien); Fric, Antonín (Praha); Friday, A. E. (Cambridge)*; Frisch (Braunschweig); Frisk, Göran (Stockholm)*; Fritsche, Karl (Bonn, Stuttgart); Fritze, Ernst A. (Wiesbaden); Frivaldszky von Frivald, Emerich & Johann (Budapest); Fuchs/Fuks, Karl (Kazan); Führer, Ludwig von (Cluj, Sarajevo, St Petersburg ZISP, Wien); Fuisz, T. (Budapest)*; Fulín, Miroslav (Kosice)*; Fülleborn, Friedrich (Berlin); Fürbringer, Max (Amsterdam); Fuss, K. (Sibiu);

Gadow, Hans F. (Cambridge); Gaimard, Joseph P. (Paris); Galathea Exp. (København); Galbraith, Ian C. J. (Tring); Gallardo (Roma); Gamauf, Anita (Wien)*; Garavini, E. (Bologna INFS); Garcia Franquesa, Eulalia (Barcelona)*; Gargallo, T. (Siracusa); Garlepp, Gustav & Otto (Frankfurt); Garnett, Marjory (Carlisle); Garnot, Prosper (Paris); Garrett, A (see Mus. Godeffroy); Gätke, Heinrich (Wilhelmshaven); Gatter, Wulf & Peer (Stuttgart); Gavetti, Elena (Torino)*; Gay, Arthur B. (Exeter); Gedroyc (Bytom); Gehringer, Fritz (Neuchâtel); Geisler, Bruno (Dresden); Geller-Grimm, Fritz (Wiesbaden)*; Gené, Giuseppe (Torino); Gengler, Josef (München); Geoffroy de St Hilaire, E. & I. (Paris); Gerber, Emanuel (Fribourg)*; Gerrard, Edward (Liverpool, Tring); Gerrard, W. T. (Liverpool); Gerschik, Jenö (Budapest); Geyr von Schweppenburg, Hans Freiherr (Bonn); Gherardesca, della (Firenze); Gherghel, P. (Cluj-Napoca); Ghigi, Alessandro (Bologna INFS); Gibson, Francis & Jabez (Saffron Walden, Essex); Giebel, Christoph Gottfried (Halle); Giglioli, Enrico H. (Firenze, Torino); Gil Lletget, Augusto (Madrid); Gilbert, John (Exeter, Leiden, Liverpool, Tring); Giriddes, Albino (Coimbra); Gladkov, Nikolai Aleksevich (Moscow ZMMU); Glowacinski, Zbigniew (Krakow); Gmelin, J. C. (Karlsruhe); Gmelin, Samuel G. (St Petersburg ZISP); Godeffroy, Johann Cesar (Bamberg, and see Mus. Godeffroy); Godet, Paul (Neuchâtel); Godlewski, Viktor (Warszawa); Godman, Frederick D. (Tring); Godman, Percy (Brighton); Godron (Nancy); Godwin-Austen, Henry H. (Tring); Goeldi, Emil A. (Bern); Goethe, Friedrich (Wilhelmshaven); Goldhagen, Johann F. G. (Halle); Goldie, A. (Tring); Gómez, Leopoldo (Barcelona, Hamburg); Goodfellow, Walter (Tring); Goodwin, Derek (Tring); Gorban, I. (Lviv); Gorton, Eric (Bolton); Gosse, Phillip A. (Cambridge, Tring); Göttingen Mus. (Hannover); Gould, John (Bern, Cambridge, Exeter, Leiden, Liverpool, Saffron Walden [Essex], Torino, Tring); Gourdon, M. (Toulouse); Grabert, M. (Stuttgart); Grabowsky, Friedrich (Berlin, Braunschweig); Gräffe, Eduard (see Mus. Godeffroy); Grant, Claude H. B. (Tring); Grant, Robert E. (London Univ. Coll.); Granvik, Sven H. (Stockholm); Grauer, Rudolf (Berlin, Wien); Gravenhorst, Johann L. C. (Wroclaw); Gray, George R. (Tring); Gray, John E. (Tring); Grayson, A. J. (Bremen); Gretzer, Hermann (Sofia); Griffith, A. F. (Brighton); Griffoli (Firenze); Grill, J. W. (Stockholm); Grimm, Hugo Oskar (Leipzig); Groh, Günter (Bad Dürkheim); Gromer, J. (Sibiu); Grote, Hermann (Berlin); Ground (Coventry); Grouw, Hein van (Leiden)*; Grube, E. (Wroclaw); Grum-Grzhimailo, G. E. & M. E. (St Petersburg ZISP); Grün, Hermann (Amsterdam, Dresden, Bonn, Frankfurt, Köln, München, Stuttgart); Gude, Hermann (Dresden, Stuttgart); Gudmundsson, Finnur (Reykjavik); Gueinzius, Wilhelm (Dresden, Leipzig); Guillemard, F. H. H. (Cambridge); Guinet, J.-M. (Luxembourg)*; Güldenstädt, Johann A. (St Petersburg ZISP); Gundlach, Johannes (Berlin, Bremen, Darmstadt, Kassel); Gunnerus, J. E. (Trondheim); Gunning, Jan W. B. (Dresden); Güntert, Marcel (Bern)*; Gurney, John H. (Cambridge, Liverpool, Tring); Gyldenstolpe, Count Nils (Stockholm); Gyseghem, Roland van (Bad Dürkheim)*;

Haag, Holger (Stuttgart)*; Haan, Günther A. L. de (Amsterdam) ; Haast, J. F. Julius von (Bremen, Frankfurt, München, Wien); Haberer, Karl A. (Karlsruhe, München); Hablizl, Carl L. (St Petersburg

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(Bytom); Söderbom, K. G. (Stockholm); Söderstrom, L. (Stockholm); Sokolov, A. M. (St Petersburg ZISP)*; Sokolov, E. P. (St Petersburg ZISP)*; Solander, Daniel (see

Mus. Leverianum); Solaroli, Count (Torino); Solheim, Roar (Kristiansand)*; Solti, B. (Pecs); Sommerfeld, Lt. (München); Sousa, Luzia (Porto)*; Sowerby, Laurence (Tring); Spangenberg, Evgenii Pavlovich (Moscow SDM, Moscow ZMMU); Sparrman, Anders (Stockholm); Spatz, Paul (Bonn, Stockholm); Speerschneider, Julius (Rudolstadt); Speke, John (Bremen); Spieß, August von (Sibiu); Spix, Johann B. von (Bamberg, Graz, München); Sprüngli, Daniel (Bern); Srebrodolska, Natalia I. (Lviv); St Helen's Mus. (Liverpool); St John, Oliver B. (Tring); Stalker, William (Tring); Stampfli, Franz X. (Leiden); Stanescu, Dan (Sibiu); Stanford, John K. (Tring); Stanley, Lord (= Earl of Derby) (Liverpool); Stawarczyk, Tadeusz (Wroclaw)*; Stechow, Eberhard (München); Stegman, Boris (St Petersburg ZISP); Stein, G. H. W. (Berlin, Lisboa-CZ/IICT); Stein, H. (Sibiu); Steinbacher, Joachim (Frankfurt); Steindachner, Franz (Wien); Steiner, Hans (Zürich); Steinheimer, Frank (Tring, Berlin*); Steller, George W. (St Petersburg ZISP); Stenhouse, John H. (Edinburgh); Stepanyan, Leo S. (Moscow Stepanyan coll.); Stephan, Burkhard (Berlin); Stetter, Friedrich W. (Sibiu); Stevens, Herbert (Newcastle); Stevens, Samuel (Cambridge, Tring); Stewart, Alexander Bannatyne (Glasgow); Stjernberg, Torsten (Helsinki)*; Stoliczka, Ferdinand (Bremen, Tring, Wien); Stolz, Johannes W. (Görlitz); Storm, Hugo (Lübeck); Strachey, R. (Tring); Strautman, Fedir I. (Lviv); Streich, F. K. Ivo (Stuttgart); Stresemann, Erwin F. T. (Berlin, München); Strickland, A. (Cambridge); Strickland, Hugh E. (Cambridge); Strickland, N. C. (Cambridge); Stuart Baker, Edward C. (Brighton, Sofia, Tring); Stubbe, Michael (Halle); Stüber, Eberhard (Salzburg)*; Studer, Theophil (Bern); Stuhlmann, Franz (Hamburg); Sturm, J. Wilhelm (München); Sturm, Johann H. C. Friedrich (Bamberg, München); Sturniolo, G. (Siracusa); Sturt, Charles (Edinburgh, Tring); Styan, Frederick W. (Tring); Sudilovskaya, Angelina Mikhailovna (Moscow ZMMU); Sundevall, Carl J. (Stockholm); Sushkin, Petr Petrovich (Moscow SDM, St Petersburg ZISP); Susic, Goran (Zagreb)*; Sutcliffe, Richard (Glasgow)*; Sutorova, Helena (Brno)*; Sutter, Ernst (Basel); Swainson, William (Cambridge, Liverpool, Wien); Swindon Mus. (Leeds); Swinhoe, Charles (Tring); Swinhoe, Robert (Leiden, Liverpool, Torino, Tring, Wien); Sykes, William H. (Tring); Symonds, Ray (Cambridge)*; Sztolcman/Stolzmann, Jan (Warszawa);

Taczanowski, Ladislaus (Warszawa); Talandis, B. (Kaunas); Talpeanu, Matei (Bucharest); Talsky, Josef (Brno); Tancré, A. (Braunschweig); Tancré, Rudolf (Amsterdam, Bonn, Braunschweig); Tangier-Smith coll. (Tring); Taschenberg, O. (Halle); Tauern, O. (München); Teixeira, Maria José (Lisboa-CZ/IICT)*; Temminck, Coenraad J. (Leiden, Torino, Wien); Tenckhoff, Adolf (Münster); Ter Meer, Hans H. (Leiden, Leipzig); Terlutter, Heinrich (Münster)*; Tesar, Josef (Brno); Tetens, A. (see Mus. Godeffroy); Teysman, J. E. (Leiden); Thaler, Konrad (Innsbruck)*; Thanner, Rudolf von (Amsterdam, Bonn, München, Roma) ; Theil, Paul (Sibiu); Themido, António A. (Coimbra); Thomä, Carl (Wiesbaden); Thomas, R. H. (Oxford); Thome, Johan (Oslo); Thorpe, D. L. (Carlisle); Thorpe, W. H. (Cambridge); Thunberg, C. P. (Uppsala); Ticehurst, Claude B. (Sevenoaks, Tring); Tichy, V. (Prerov); Tickell, Samuel R. (Tring); Tiemann, F. (Halberstadt, Wroclaw); Tobias, Robert (Görlitz); Tomek, Teresa (Krakow)*; Tomialojc, Ludwik (Wroclaw)*; Tomkovich, Pavel S. (Moscow ZMMU)*; Toschi, Augusto (Bologna INFS); Toufar, Jirí (Prerov); Tozzi (Firenze); Tradescant, John (Oxford); Tratz, Eduard P. (Salzburg); Treacher, W. H. (Oxford); Trense, W. (Hamburg); Treskow, Arthur von (Berlin); Trischitta, Antonino (Terrasini); Tristram, Henry B. (Liverpool, Tring); Trojan, Przemslav (Warszawa)*; Tröster, Gert (Göttingen)*; Tschudi, Johann J. von (Neuchâtel, Wien); Tschusi zu Schmidhoffen, Viktor von (Graz, München, Roma, Salzburg, Wien); Tugarinov, A.Ya. (St Petersburg ZISP); Tuke, W. M. (Saffron Walden, Essex); Tullberg, Tycho F. (Stockholm); Tunstall, Marmaduke (Newcastle); Turati, Count Ercole (Milano); Turchetto, M. (Padova)*; Turov, S. S. (Moscow-ZMMU); Tutis, Vesna (Zagreb)*; Tweeddale, Marquis of (Tring); Tychsen, Oluf G. (Rostock);

Ulianovsky, A. (Lviv); Underwood (Wien); Unger, Jakob (Bonn, Frankfurt, Karlsruhe); Urbanek, Josef (Praha); Uribe, Francesc (Barcelona)*; Ursch (Strasbourg); Uspenskii, Savva Mikhailovich (Moscow-ZMMU); Ussher, H. T. (Bremen, Tervuren);

Vach, Miloslav (Praha); Vader, Wim (Tromsø)*; Väisänen, Risto A. (Helsinki)*; Vallisneri, Antonio (Padova); Valverde, Jose A. (Sevilla); Van den Elzen, Renate (Bonn)*; Van Someren, Robert A. L. (Edinburgh); Van Someren, Victor G. L. (Edinburgh); Vandelli, Domingos (Coimbra, Lisboa-MB); Vasic, Vaslav (Beograd)*; Vasiliu, M. (Suceava); Vaskelis, J. (Kaunas); Vaucher, A. (Genève); Vazvári, Nikolaus (Budapest); Venezia, Francesco (Terrasini); Verbis, Z. (Prerov); Verheyen, René & Rudolf (Brussels); Vermouzek, Zdenèk (Olomouc)*; Veron, Géraldine (Paris)*; Verreaux, Édouard & Jules P.

(Bremen, Halberstadt, Leiden, Liverpool, Milano, Paris, Wien); Vian (Nantes); Vick, G. (Brighton); Victorin, J. F. (Stockholm); Vieillot, Louis J. P. (Paris); Vieire, Lopez (Coimbra); Vierthaler, Richard (Bremen, Bonn); Vigors, Nicholas A. (Tring); Vik, Rolf (Oslo); Vilmarest-de Cossette coll. (Lille); Vincent, J. (Tring); Violani, Carlo (Pavia)*; Vitale, Antonino (Terrasini)*; Vitalis (Grenoble); Voboril, Jan V. (Praha); Vodolazskaya, Tatyana (Kazan)*; Vogelschutzwarte Neschwitz (Görlitz); Voinstvensky, M. (Kiev); Voipio, Paavo (Helsinki, Turku); Voisin, Claire (Paris)*; Voisin, Jean-François (Paris)*; Volchanecky, I. B (Saratov); Volponi, S. (Ferrara); Volz, Walter (Bern, Wroclaw); Voous, Karel H. (Amsterdam); Vorderman, A. G. (Leiden); Vouga, Claude (Lausanne); Voy. Alert (Tring); Voy. Astrolabe & Zélée (Paris); Voy. Astrolabe (Paris); Voy. Beagle (Liverpool, Tring); Voy. Blossom (Tring); Voy. Challenger (Tring); Voy. Coquille (Paris); Voy. Endeavour (see Mus. Leverianum); Voy. Erebus & Terror (Tring); Voy. Eugenie (Stockholm); Voy. Gazelle (Berlin); Voy. Géographe (Paris); Voy. Herald (Tring); Voy. Magenta (Firenze, Torino); Voy. Maud (Stavanger); Voy. Nadezhda (St Petersburg ZISP); Voy. Naturaliste (Paris); Voy. Novara (Wien); Voy. Rattlesnake (Tring); Voy. Resolution (see Mus. Leverianum); Voy. Rosenberg (Tervuren); Voy. Senyavin (St Petersburg ZISP); Voy. Sulphur (Tring); Voy. Urania (Paris); Voy. Vega (Stockholm); Voy. Vénus (Paris); Voznesenski, I. G. (St Petersburg ZISP); Vráz, Enrico Stanko (Brno, Prerov);

Wachs, Horst (Rostock); Wadén, Sverker (Malmö)*; Wagler, Johann G. (München); Wagner, Andreas (München); Wagner, H. O. (Bremen); Wagstaffe, Reginald (Liverpool); Wahlberg, Johan A. (Bremen, Stockholm, Uppsala); Wahnes, Carl (Dresden); Wakefield Mus. (Leeds); Waldeck Sr., Carel (Amsterdam) ; Wallace, Alfred R. (Liverpool, Tring); Wallenstein de Vella, T. Carol (Karl Walstein) (Bucharest); Wallrow, J. (Bolton); Walrond, Sir John (Exeter); Walters, Michael (Tring); Wandhammer, Marie-Dominique (Strasbourg)*; Wandres (Karlsruhe); Ward, A. E. (Tring); Wardlaw-Ramsay, Robert G. (Edinburgh, Tring); Warga, Kálmán (Budapest); Wasmuth, Paul (Tallinn); Wassenius, Ernst (Helsinki); Waterhouse, G. R. (Tring); Waterstradt, Johannes (København, Tring); Watkins, H. & C. (München); Wattel, Jan (Amsterdam); Weber (Genève); Weber, Erich (Tübingen)*; Weber, G. A. (Bremen); Weber, Max (Amsterdam); Webster, Frank B. (Liverpool); Wechsler, Klaus (Bremen)*; Wehrung (Strasbourg); Weigl, Stefan (Linz)*; Weigold, Max Hugo (Berlin, Dresden, München, Wilhelmshaven); Weiler, Justus (Wiesbaden); Weiske, Emil (Bamberg, Berlin, Dresden, Leipzig, Rudolstadt, Tring, Wien); Weiß, Karl (Bremen, Halberstadt, Hamburg); Weisz, Tibor (Bardejov); Werner, Emil (Sofia); Wertheim, C. J. M. (Amsterdam); Westin, General (Stockholm, Uppsala); Wettstein, Otto Ritter von (Wien); Weyns, Lt.-Col. A. F. G. (Tervuren); Whistler, Hugh (Edinburgh, Tring); Whitaker, Joseph I. S. (Edinburgh, Tring); Whitchurch Mus. (Ludlow); White, C. M. N. (Oxford); Whitehead, Charles H. T. (Tring); Whitehead, John (Tring); Whiteley, D. (Sheffield); Whitfield (Liverpool); Whitmee, Samuel (Liverpool); Whyte, Alexander (Liverpool, Tring); Wibeck, Edward (Jönköping); Wickevoort Crommelin, Jan P. van (Leiden); Wiedenfeld, Lothar von (München); Wied-Neuwied, Maximilian A. P. Prinz zu (Bremen); Wieninger, George (Linz); Wiglesworth, Lionel W. (Cambridge, Dresden); Willgohs, Johan F. (Bergen); Williams, A. E. (Uppsala); Williams, J. B. (Birmingham); Williams, John G. (Liverpool, Uppsala); Willmann, Rainer (Göttingen)*; Wills, M. A. (Oxford)*; Wilson, Edward (Tring); Wilson, S. B. (Cambridge); Wingate, A. W. S. (Tring); Winge, Herluf (København); Winkler, Raffael (Basel)*; Wirth, V. (Karlsruhe)*; Witherby, Harry F. (Tring); Witting, E. (Sibiu); Wollaston, A. F. R. Sandy (Tring); Wolters, Hans E. (Bonn); Woodford, Charles M. (Tring); Woog, Friederike (Stuttgart)*; Worofka (Graz); Worthen, Charles K. (Tring); Wright, Magnus von (Helsinki); Wunderer, Hansjörg (Regensburg)*; Würdinger, I. (Sibiu); Württemberg, Carl-Eugen Herzog von (Stuttgart); Württemberg, Paul W. Herzog von (Bremen, Stuttgart, Tübingen); Wyrwich, P. (Hamburg);

Xántus, Johann (Bremen, Budapest); Yen, K.Y. (Paris); Yerbury, John W. (Tring); Yudin, K. A. (St Petersburg ZISP); Zaffagnini (Bologna MZUB); Zarudny, Nikolai A. (St Petersburg ZISP); Zavyalov, Evgeny V. (Saratov)*; Zdobnitzky, Franz (Brno); Zedlitz und Trützschler, Otto Graf von (Stockholm); Zelebor, Johann (Wien); Zenatello, Marco (Bologna INFS)*; Zenker, E. (Wiesbaden); Zenker, Georg (Berlin); Zielinski, S. (Warszawa); Zimmer, Carl (München, Wien, Wroclaw); Zimmermann (Bremen); Zimmermann, Robert (Berlin); Ziswiler, V. (Zürich)*; Zittwitz, Julius von (Görlitz); Zoological Society of London (Tring); Zoologisches Institut Freiburg (Karlsruhe); Zubarovsky, V. (Kiev); Zuffi, Marco A. L. (Pisa)*; Zugmayer, Erich (München).

Appendix 3

Numbers of bird skins, mounts and other items in scientific collections

(1) Numbers in collections in **Europe**, according to the data supplied by the curators, in sequence from large to small as far as skins and mounts are concerned, omitting collections with fewer than 2,500 study skins and mounts or fewer than 5,000 bird items. The number of all bird items available is often far from exact and therefore is not used for establishing ranking order.

Rank	Town	Skins & mounts	*All bird items
1	Tring	756,000	1,291,000
2	Leiden	170,000	214,000
3	St-Petersburg ZISP	170,000	190,000
4	Paris	161,000	177,000
5	Tervuren	150,000	167,500
6	Berlin	142,000	157,000
7	Moscow ZMMU	117,000	131,000
8	Stockholm	105,000	146,000
9	Vienna/Wien	104,300	125,000
10	Copenhagen/København	97,000	138,000
11	Frankfurt am Main	90,000	102,500
12	Bonn	76,000	136,000
13	Brussels	71,300	100,000
14	Stuttgart	70,000	95,000
15	Dresden	70,000	90,000
16	Edinburgh	63,000	100,000
17	Munich/München	60,000	61,000
18	Amsterdam	53,000	60,000
19	Liverpool	51,500	64,500
20	Cambridge	40,000	50,500
21	Warszawa	40,000	50,000
22	Kiev	40,000	42,500
23	Milan/Milano	34,000	36,000
24	Hamburg	30,000	58,000
25	Genoa/Genova	30,000	32,000
26	Helsinki	29,000	63,000
27	Braunschweig	27,000	31,000
28	Gothenburg/Göteborg	25,000	43,000
29	Genève	25,000	34,000
30	Oslo	25,000	33,000
31	Basel	25,000	31,000
32	Nantes	22,100	31,500
33	Prague/Praha	22,000	27,500
34	Seville/Sevilla	22,000	25,000
35	Turin/Torino	21,000	22,000
36	Lund	20,000	31,000
37	Cardiff	20,000	29,000
38	Bremen	20,000	?
39	Sevenoaks	19,500	19,500
40	Madrid	19,000	29,000
41	Oxford	19,000	23,000
42	Florence/Firenze	18,000	28,000
43	Halberstadt	18,000	26,000
44	Manchester	16,500	28,000
45	Sofia	15,500	31,000
46	Rome/Roma	15,000	?
47	Coburg	14,500	17,500
48	Reykjavik	14,000	19,000
49	Bern	13,200	23,500
50	Budapest	12,500	16,000
51	Newcastle	12,000	23,200
52	Wroclaw	12,000	14,000
53	Moscow SDM	11,000	12,200
54	Lille	11,000	11,000
55	Sarajevo	10,234	11,500
56	Brighton	10,000	28,500
57	Neuchâtel	10,000	12,000
58	Pisa	10,000	12,000
59	Bologna	9,700	10,000
60	Halle	9,100	21,000
61	Hanover/Hannover	9,000	16,500
62	Grenoble	9,000	9,300
63	Toulouse	8,900	12,200
64	Tartu	8,500	13,600
65	Exeter	8,500	10,000
66	Linz	8,200	12,500
67	Terrasini	8,000	9,000
68	Brno	8,000	?
69	Kaunas	7,630	10,200
70	Bristol	7,500	11,000
71	Lausanne	7,000	8,800
72	Barcelona	7,000	8,400
73	Kiel	7,000	57,000
74	Uppsala	6,900	?
75	Wiesbaden	6,800	13,000
76	Görlitz	6,800	9,800
77	Zagreb	6,700	7,300
78	Glasgow	6,400	9,300
79	Lisbon CZ/IICT	6,340	6,700
80	Leipzig	6,250	11,600
81	Bergen	6,200	10,000
82	Magdeburg	6,200	7,400

*skins, mounts, skeletons, in alcohol, egg sets, nests

83	Prerov	6,100	11,000
84	Bardejov	6,000	10,500
85	Bucharest	6,000	8,500
86	Münster	6,000	7,000
87	Bratislava	6,000	?
88	Wilhelmshaven	5,500	8,000
89	Fribourg	5,300	7,200
90	Bolton	5,000	11,200
91	Belgrade/Beograd	5,000	6,000
92	Karlsruhe	5,000	6,000
93	Verona	5,000	5,500
94	Tournai	4,700	4,750
95	Leeds	4,500	7,600
96	St-Petersburg SPBU	4,500	5,700
97	Stavanger	4,200	?
98	Tromsø	4,100	5,500
99	Carlisle	4,000	6,700
100	Zürich	4,000	4,900
101	Pavia	4,000	?
102	Opava	4,000	?
103	Forli	4,000	?
104	Altenburg	3,600	4,100
105	Reghin	3,600	?
106	Moscow MPSU	3,500	3,500
107	Ljubljana	3,500	3,600
108	Leeuwarden	3,500	3,800
109	Lviv	3,500	4,100
110	Coimbra	3,200	4,500
111	Trondheim	3,200	3,400
112	York	3,100	3,600
113	Kosice	3,000	7,250
114	Olomouc	3,000	4,773
115	Nancy	3,000	?
116	Salzburg	3,000	?
117	Mainz	2,875	6,000
118	Moscow Stepanyan	2,800	2,800
119	Luxembourg	2,600	3,000
120	Siena	2,600	2,650
121	Sibiu	2,550	4,000
123	Turku	2,500	4,000
124	Novi Sad	2,500	3,000
125	Athens/Athinai	2,500	2,750
126	Venice/Venezia	2,500	2,600
127	Rotterdam	2,200	8,000
128	Krakow	1,400	7,600
129	Witney	?	12,000
130	Moscow (PINRAS)	0	5,500

The total number of skins in European collections is at least 4,000,000.

(2) **Outside Europe**. For comparison, some non-European collections have the following number of bird skins and mounts (*fide* Banks *et al.* 1973, Davis and Jackson 1995, Mearns and Mearns 1998, Gill 2001), but note that some figures are rather outdated, especially those of Banks *et al.* (1973).

New York (American Mus. of Nat. Hist.)	900,000
Washington (Natl. Mus. of Nat. Hist.)	600,000
Chicago (Field Museum of Nat. Hist.)	390,000
Harvard (Mus. of Comparitive Zool.)	320,000
Ann Arbor (Univ. of Michigan)	180,000
Pittsburgh (Carnegie Mus.)	170,000
Philadelphia (Acad. Nat. Sci.)	163,000
Berkeley (Mus. of Vertebr. Zool.)	160,000
Ontario (Royal Ontario Mus.)	134,000
Baton Rouge (Mus. Nat. Sci. Louisiana)	133,500
Ottawa (Canadian Mus. of Nature)	120,000
Los Angeles (LA County Mus. Nat. Hist.)	95,000
Bulawayo (Nat. Hist. Mus. Zimbabwe)	90,000
San Francisco (California Acad. Sci.)	83,000
New Haven (Peabody Mus., Yale Univ.)	80,000
Caracas (Colección Ornitológia Phelps)	76,000
Los Angeles (Moore Lab. of Zool.)	67,000
Lawrence (Univ. of Kansas)	55,000
Sydney (Australian Mus.)	48,000
Pretoria (Transvaal Mus.)	40,000
San Diego (San Diego Nat. Hist. Mus.)	37,000
Los Angeles (Univ. of California)	36,500
Melbourne (Museum of Victoria)	36,000
Denver (Denver Mus. of Nat. Hist.)	35,000
Ithaca (Cornell Univ., New York)	34,200
Adelaide (South Australian Mus.)	30,446
Durban (Durban Nat. Sci. Mus.)	30,140
Abiko (Yamashina Institute, Japan)	30,000+
Nairobi (National Museums of Kenya)	30,000
Greenville (Delaware Mus. Nat. Hist.)	25,000
Salt Lake City (University of Utah)	25,000
Minneapolis (University of Minnesota)	25,000
Cleveland (Cleveland Mus. Nat. Hist.)	24,000
Blacksburg (Virginia Polytec. Inst. State Univ.)	20,060
Livingstone (Livingstone Mus., Zambia)	20,000
Wellington (Mus. of New Zealand)	20,000

The total number of skins of all non-European collections is at least *c.*5,000,000, of which USA and Canada have at least 4,000,000.

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Extinct and endangered ('E&E') birds: a proposed list for collection catalogues

by M. P. Adams, J. H. Cooper & N. J. Collar

SUMMARY

Specimens of extinct and endangered ("E&E") birds are often, and rightly, the subject of elevated curatorial vigilance and care, and the publication of museum holdings of such species is regarded as a valuable contribution to conservation information. However, the definition of E&E species has varied over time and has in part been a matter of curatorial discretion. Using the species listed in BirdLife International's (2000) *Threatened birds of the world*, but setting filters to eliminate species whose population levels are likely to remain high, we derive a list of 481 species (129 extinct, 352 extant) which we propose as core to any E&E list; local, national, regional or taxonomic interests might prompt individual museums to include other taxa in their 'E&E' lists.

The publication of lists of museum specimens deemed to be rare, chiefly because the species they represent are deemed to be rare, has been a preoccupation of curators of museums for many years. In part this is a valuable public service, drawing attention to material which may have relevance to an understanding of the conservation options for the species in question, and possibly reducing the necessity for further collecting of particular taxa by indicating the availability of material (Snow 1972); and in part it is a practical means of demonstrating to the world the global significance of a particular collection. Ever since the synthesis by Phillips (1929), but particularly following the appearance of Greenway (1958, 1967) and the various editions of the Red Data Books of ICBP (now BirdLife International) from the 1960s, opportunities have arisen for museums to publish their holdings with respect to species identified as extinct or as at risk of extinction (without pretending this to be an exhaustive list, we know of: Berlioz 1935, Meyer de Schauensee 1941, Stresemann 1954, Mertens & Steinbacher 1955, Steinbacher 1959, Jouanin 1962, Howes 1969, Benson 1972, Fisher 1981, Violani *et al.* 1984, Torres-Mura 1991 and, of course, Knox & Walters 1994 and Boev 2003).

During discussions at the workshops (14–15 November 1999) following the conference 'Why Museums Matter', the seeds were sown for two major inventory projects: (i) a global database of avian type specimens, and (ii) a similar inventory and catalogue covering international holdings of extinct and endangered ('E&E') species (Cooper & Steinheimer 2003). The first of these is now well under way, founded on the amalgamated existing type catalogues of several major institutions, which happily include some of the largest type collections in the world (Bruckert in press); having such catalogues already in existence has proved a great advantage to the type project. However, E&E collections are not yet covered to the same degree and compilation of a global, or even European, catalogue will therefore, for the time being, remain a longer-term prospect.

A fundamental problem raised at the meeting is that the world list of E&E birds is by no means static—indeed it is unfortunately steadily on the increase—nor are there agreed criteria for what is most appropriate to include. Clearly, if an international catalogue is to become a reality, it must be based on a standard, unifying species list. By introducing such a list here, based on the publication of *Threatened birds of the world* (BirdLife International 2000), we hope to provide an objective starting point for any institution considering its own E&E catalogue and also for the integration of such catalogues in the future. However, compilation of an E&E catalogue may prove to be a time-consuming task, especially for larger collections. An initial step should therefore be to use the list provided here to compile a simple inventory of numbers of specimens held; such an inventory should ideally include all specimens—not only skins, but also skeletons, fluid preserved material, and eggs.

The original Natural History Museum (Tring) catalogue of E&E bird species (Knox & Walters 1994) was based on a species list generated from a combination of publications, primarily the ICBP Red Data Books, using objective criteria where possible. However, assimilating species data from multiple sources in this way is a complex task, and in the absence of a comprehensive categorised source many endangered taxa were omitted, as the authors pointed out (Knox & Walters 1994: 7). A single source of information and a simple system of decision-making are therefore preferable, and BirdLife International (2000) now offers a convenient, up-to-date and objectively assessed solution to this problem with details of both endangered and extinct species.

Specimens of extinct and endangered birds may be historically interesting or scientifically important, but above all they are either irreplaceable or very nearly so. In the preface of Knox & Walters (1994: 1), David Snow emphasised the continuing 'need to conserve as carefully as possible and obtain the greatest possible amount of information from specimens of extinct and threatened species that have already been collected'. We fully endorse this need; for, put bluntly, new specimens of these species are likely to reach collections only very infrequently, and we must therefore preserve with particular care what material we already have. On the occasions that these species do reach collections, we must be aware that we have a responsibility to preserve them in the most suitable way and to maximise the material saved.

The extra care with which E&E specimens are treated normally means setting them aside in restricted-access cabinets. However, while it remains important to know what E&E material is held in any given institution, it is clearly impractical, probably undesirable and often plainly unnecessary to place all globally threatened species in a designated E&E collection. Some species will simply be too numerous in the wild and/or in collections to warrant or even to allow removal to a separate secure holding. Moreover, there are simply too many threatened species for a comprehensive E&E security exercise: apart from the 128 extinctions since 1500, BirdLife International (2000) documents no fewer than 1,186 species that are globally threatened. Our aim has therefore been to reduce this list to those species whose global populations are most numerically weak, and therefore least likely to yield many (or any) new specimens in the foreseeable future. We have selected among the IUCN criteria applied by and outlined in BirdLife International (2000), excluding all species which qualify under category A (rapid decline irrespective of population size) and including a subset of species on the basis of small range and/or small population size, factors that indicate a species's overall scarcity and therefore the low likelihood of specimens having reached (or ever now reaching) museum collections. A summary of all IUCN Red List categories—for the complete version see IUCN (2001)—is given in Table 1; our chosen criteria (and their categories) are given in Table 2. We use criteria triggering the categories Extinct, Extinct in the Wild, Critically Endangered, Endangered and Vulnerable; we omit the categories Conservation Dependent, Near Threatened and Data Deficient.

We include all 128 Extinct (EX) species listed by Brooks (2000) plus one extra (see legend to Appendix). This comprises all those judged to have gone extinct since 1500, and is restricted to valid taxonomic entities and full biological species. Although some published E&E lists, including Knox and Walters (1994), treat subspecies, we resist doing so here, because it makes sense to maintain conformity with Brooks (2000) and BirdLife International (2000), because there *are* no global lists of extinct and/or endangered subspecies, and because there is little scope for generating such lists with appropriate authority in the near future. Nevertheless, this is not at all to imply that subspecies have no place in E&E collections: if curators use, at least as a starting point, the subspecies treated in King (1978-1979)—where these have not been elevated to species level or where the taxa do not themselves already comprise a threatened species—they have a valuable starting point.

We include all three Extinct in the Wild (EW) species listed in BirdLife International (2000). These are species that are 'known only to survive… in captivity or as a naturalised population (or populations) well outside the past range' (BirdLife International 2000).

We select those Critically Endangered (CR) species that meet the criteria for small declining range, small declining population and/or very small population (see Table 2). Effectively, this filters out species that may be experiencing rapid population declines but nevertheless still have relatively widespread and probably at least moderate current populations, and are likely to be represented well enough in certain collections, such as White-rumped Vulture *Gyps bengalensis* and Long-billed Vulture *G. indicus*. Even so, the number of CR species only drops from 182 to 170.

We accept only those Endangered (EN) and Vulnerable (VU) species that are numerically rare in the wild. Species classified as Vulnerable owing to very small

TABLE 1

IUCN Red List criteria for determining degree of threat (BirdLife International 2000).

Criterion	Definition
A	Rapid population reduction
B	Small range and fragmented, declining or fluctuating
C	Small population and declining
D1	Very small population
D2	Very small range
E	Quantitative analysis

TABLE 2
IUCN Red List criteria used to determine species included in the proposed E&E list (edited from complete set of criteria given in BirdLife International 2000: 22-23).

Threat category	General criterion	Main criterion
Extinct (EX)	no reasonable doubt that last individual dead (since 1500)	—
Extinct in the Wild (EW)	Only known to survive in captivity	—
Critically Endangered (CR)	**B** small range and fragmented, declining or fluctuating	extent of occurrence estimated <100km²
	C small population and declining	population <250 mature individuals
	D1 very small population	population <50 mature individuals
Endangered (EN)	**D1** very small population	population <250 mature individuals
Vulnerable (VU)	**D1** very small population	population <1,000 mature individuals

range (typically <100 km²) are omitted, thereby removing from the list species whose populations may still be relatively large, such as White-necked Petrel *Pterodroma cervicalis* which, despite a breeding range of only 2 km², has a stable population of *c.*50,000 pairs. The effect of these filters is to reduce the EN list from 321 to 106 and the VU list from 680 to 73. (Interestingly, the result is fewer VU species than EN ones, despite the fact that the filter is more stringent on EN species, where the numerical threshold is 250 individuals, than it is on VU species, where the threshold is 1,000.)

By virtue of these filters, the basic list of E&E species reduces by almost two-thirds, from 1,315 (1,186 + 129) to 481 (see Appendix). It needs to be stressed, however, that the system used in deriving this figure cannot be expected to provide for every circumstance. Among the excluded species are such notable 'rarities' as Blue-billed Curassow *Crax alberti*, Bornean Peacock Pheasant *Polyplectron schleiermacheri*, Moluccan Woodcock *Scolopax rochussenii*, Purple-winged Ground Dove *Claravis godefrida*, Tolima Dove *Leptotila conoveri*, Madagascar Red Owl *Tyto soumagnei*, Flores Scop Owl *Otus alfredi*, Recurve-billed Bushbird *Clytoctantes alixii*, Black-hooded Antwren *Formicivora erythronotos*, Slender Antbird *Rhopornis ardesiaca*, Noisy Scrubbird *Atrichornis clamosus*, Van Dam's Vanga *Xenopirostris damii*, Grey-crowned Crocias *Crocias langbianis* and Biak Monarch *Monarcha brehmii*. These are all long-recognised species which are now, and are very likely to remain, extremely rare in museum collections. Nevertheless, all are species which BirdLife International (2000) has reasonably assumed to be at least moderately numerous in the wild. Other absentees are a host of relatively newly described species, among them Udzungwa Forest Partridge *Xenoperdix udzungwensis*, Okinawa Rail *Gallirallus okinawae*, Talaud Rail *Gymnocrex talaudensis*, El Oro Parakeet *Pyrrhura orcesi*, Congo Bay Owl *Phodilus prigoginei*, Itombwe Nightjar *Caprimulgus prigoginei*, Orange-bellied Antwren *Terenura sicki*, Grey-winged Cotinga *Tijuca* *condita*, Kaempfer's Tody-tyrant *Hemitriccus kaempferi*, Sidamo Lark *Heteromirafra sidamoensis*, Appert's Greenbul *Phyllastrephus apperti*, Apolinar's Wren *Cistothorus apolinari*, Rusty-throated Wren Babbler *Spelaeornis badeigularis*, Algerian Nuthatch *Sitta ledanti* and Chocó Vireo *Vireo masteri*, some of which are known by one or two specimens only and (again) none of which is likely to be represented by large series in the foreseeable future.

Such apparent anomalies are an inevitable consequence of the clear yet crude filtering mechanism we apply, but we doubt whether further adjustment would optimise the resulting list (which will in any case, as noted earlier, always be changing with changes in the status of species over time). It is perfectly reasonable that museum curators might want to adjust our proposed E&E list according to their own perceptions and interests. This might be because they decide that certain additional species treated in BirdLife International (2000), such as those listed in the preceding paragraph, ought to be included; but it might also be because they hold specimens of species that are in some way rare or threatened or indeed extinct at the local, national, regional or taxonomic (subspecific) level; or because they are aware of 'museum rarity', irrespective of the situation in the wild, and choose to act on that basis also—a good example would be the White-winged Potoo *Nyctibius leucopterus*, which probably occurs throughout Amazonia and is therefore not treated at all by BirdLife International, but which apparently remains known from three specimens only (Holyoak 2001). Rarity in collections irrespective of global conservation status is clearly a valid criterion for extra curatorial care, but only when museum catalogues are much more advanced and widely available will it be possible to establish a moderately robust system for identifying such species.

Nevertheless, we propose that the 481 species in the Appendix serve as the basic elements of new E&E initiatives in museums; whatever else might be added to this number, we submit that, for the sake of clarity when information is ultimately available to be pooled, nothing should at present be subtracted from it. Of course, how the birds on this Appendix are to be treated must remain a matter of curatorial discretion. In some cases they might simply be tagged as 'E&E' in a museum catalogue database (it is, naturally, desirable to tag *all* globally threatened birds in such a database), so that the information can at least be made more immediately accessible and more widely available; in some cases they may be left where they are but given some additional curatorial attention; and in some they may be removed to separate, locked cabinets.

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Appendix

Part A. Proposed list of extinct bird species for collections inventories and catalogues. In this tabulation, information on range is added for convenience, along with date of last sighting, as given by Brooks in BirdLife International (2000). Asterisked (*) entries indicate additions to the BirdLife database since the publication of BirdLife International (2000). Sword-marked (†) entries denote species that are known only from fossils, paintings or traveller's descriptions, not from 'recent' full or partial specimens, and thus can only be expected to enter E&E collections as skeletal material.

Family	Scientific Name	Common Name	Red List Category	Range	Year Last Seen
Dromaiidae	*Dromaius ater*	King Island Emu	EX	Australia	1850
	†*Dromaius baudinianus*	Kangaroo Island Emu	EX	Australia	1827
Podicipedidae	*Podiceps andinus*	Colombian Grebe	EX	Colombia	1977
	Podilymbus gigas	Atitlán Grebe	EX	Guatemala	1986
Procellariidae	†*Bulweria bifax*	St Helena Bulwer's Petrel	EX	St Helena	1550
	†*Pterodroma rupinarum*	St Helena Gadfly Petrel	EX	St Helena	1550
Hydrobatidae	*Oceanites maorianus*	New Zealand Storm Petrel	EX	New Zealand	1850
Phalacrocoracidae	*Phalacrocorax perspicillatus*	Pallas's Cormorant	EX	Galapagos Islands	1850
Ardeidae	*Ixobrychus novaezelandiae*	New Zealand Little Bittern	EX	New Zealand	1900
	†*Nycticorax duboisi*	Réunion Night Heron	EX	Mascarenes	1674
	†*Nycticorax mauritianus*	Mauritius Night Heron	EX	Mascarenes	1700
	†*Nycticorax megacephalus*	Rodrigues Night Heron	EX	Mascarenes	1761
Threskiornithidae	†*Threskiornis solitarius*	Réunion Flightless Ibis	EX	Mascarenes	1750
Anatidae	†**Alopochen kervazoi*	Réunion Island Sheldgoose	EX	Mascarenes	1674
	†*Alopochen mauritianus*	Mauritian Shelduck	EX	Mascarenes	1698
	†*Anas marecula*	Amsterdam Island Duck	EX	Amsterdam Island	1800
	†*Anas theodori*	Mauritian Duck	EX	Mascarenes	1710
	Camptorhynchus labradorius	Labrador Duck	EX	Canada & USA	1875
	Mergus australis	Auckland Island Merganser	EX	Auckland Islands	1902
Falconidae	*Caracara lutosus*	Guadalupe Caracara	EX	Guadalupe	1900
Phasianidae	*Argusianus bipunctatus*	Double-banded Argus	EX	?Malaysia	1900
	Coturnix novaezelandiae	New Zealand Quail	EX	New Zealand	1875
Rallidae	†*Aphanapteryx bonasia*	Red Rail	EX	Mascarenes	1700
	†*Aphanapteryx leguati*	Rodrigues Rail	EX	Mascarenes	1761
	Aramides gutturalis	Red-throated Wood Rail	EX	Peru	1850
	†*Atlantisia elpenor*	Ascension Flightless Crake	EX	Ascension Island	1815
	†*Atlantisia podarces*	St Helena Crake	EX	St Helena	1550
	Cabalus modestus	Chatham Rail	EX	Chatham Islands	1900
	†*Fulica newtoni*	Mascarene Coot	EX	Mascarenes	1693
	Gallinula nesiotis	Tristan Moorhen	EX	Tristan da Cunha	1900
	Gallirallus dieffenbachii	Dieffenbach's Rail	EX	Chatham Islands	1872
	†*Gallirallus pacificus*	Tahiti Rail	EX	Tahiti	1940
	Gallirallus sharpei	Sharpe's Rail	EX	Indonesia	1900
	Gallirallus wakensis	Wake Island Rail	EX	Wake Island	1945
	Nesoclopeus poecilopterus	Bar-winged Rail	EX	Fiji	1973
	Porphyrio albus	Lord Howe Island Swamphen	EX	Lord Howe Island	1834
	†*Porphyrio coerulescens*	Réunion Gallinule	EX	Mascarenes	1730

	†*Porphyrio mantelli*	North Island Takahe	EX	New Zealand	1850
	†*Porphyrio kukwiedei*	New Caledonia Gallinule	EX	New Caledonia	1860
	†*Porzana astrictocarpus*	St Helena Rail	EX	St Helena	1550
	Porzana monasa	Kosrae Crake	EX	Caroline Islands	1875
	†*Porzana nigra*	Miller's Rail	EX	Tahiti	1800
	Porzana palmeri	Laysan Crake	EX	Hawaiian Islands	1944
	Porzana sandwichensis	Hawaiian Crake	EX	Hawaiian Islands	1884
Haematopodidae	*Haematopus meadewaldoi*	Canary Islands Oystercatcher	EX	Canary Islands	1950
Scolopacidae	†*Prosobonia ellisi*	White-winged Sandpiper	EX	Society Islands	1800
	Prosobonia leucoptera	Tahitian Sandpiper	EX	Tahiti	1800
Alcidae	*Pinguinus impennis*	Great Auk	EX	North Atlantic	1852
Raphidae	†*Pezophaps solitaria*	Rodrigues Solitaire	EX	Mascarenes	1770
	Raphus cucullatus	Dodo	EX	Mascarenes	1662
Columbidae	*Alectroenas nitidissima*	Mauritius Blue Pigeon	EX	Mascarenes	1840
	†*Alectroenas rodericana*	Rodrigues Pigeon	EX	Mascarenes	1750
	†*Columba duboisi*	Réunion Pigeon	EX	Mascarenes	1750
	Columba jouyi	Ryukyu Pigeon	EX	Okinawa & Daito Is.	1936
	Columba versicolor	Bonin Woodpigeon	EX	Bonin Is.	1889
	†*Dysmoropelia dekarchiskos*	St Helena Dove	EX	St Helena	1550
	Ectopistes migratorius	Passenger Pigeon	EX	USA & Canada	1914
	†*Gallicolumba ferruginea*	Tanna Ground Dove	EX	Vanuatu	1800
	†*Gallicolumba norfolciensis*	Norfolk Island Ground Dove	EX	Norfolk Island	1800
	Microgoura meeki	Choiseul Pigeon	EX	Solomon Islands	1904
	Ptilinopus mercierii	Red-moustached Fruit Dove	EX	Marquesas Islands	1950
Psittacidae	†*Amazona martinicana*	Martinique Parrot	EX	Martinique	1800
	†*Amazona violacea*	Guadeloupe Parrot	EX	Guadalupe	1800
	†*Ara atwoodi*	Dominican Green-and-yellow Macaw	EX	Dominica	1850
	†*Ara erythrocephala*	Jamaican Green-and-yellow Macaw	EX	Jamaica	1850
	†*Ara gossei*	Jamaican Red Macaw	EX	Jamaica	1800
	†*Ara guadeloupensis*	Lesser Antillean Macaw	EX	Guadalupe	1800
	Ara tricolor	Cuban Macaw	EX	Cuba	1850
	†*Aratinga labati*	Guadeloupe Parakeet	EX	Guadalupe	1800
	Conuropsis carolinensis	Carolina Parakeet	EX	USA	1918
	Cyanoramphus ulietanus	Raiatea Parakeet	EX	Raiatea	1773
	Cyanoramphus zealandicus	Black-fronted Parakeet	EX	Society Islands	1850
	†*Lophopsittacus bensoni*	Mauritius Grey Parrot	EX	Mascarenes	1800
	†*Lophopsittacus mauritianus*	Broad-billed Parrot	EX	Mascarenes	1700
	Mascarinus mascarinus	Mascarene Parrot	EX	Mascarenes	1834
	†*Necropsittacus rodericanus*	Rodrigues Parrot	EX	Mascarenes	1761
	Nestor productus	Norfolk Island Kaka	EX	Norfolk Islands	1851
	Psephotus pulcherrimus	Paradise Parrot	EX	Australia	1927
	Psittacula exsul	Newton's Parakeet	EX	Mascarenes	1875
	Psittacula wardi	Seychelles Parakeet	EX	Seychelles	1900
Cuculidae	*Coua delalandei*	Snail-eating Coua	EX	Madagascar	1834
	†*Nannococcyx psix*	St Helena Cuckoo	EX	St Helena	1800

Strigidae	†*Mascarenotus grucheti*	Réunion Owl	EX	Mascarenes	1650
	†*Mascarenotus murivorus*	Rodrigues Owl	EX	Mascarenes	1726
	†*Mascarenotus sauzieri*	Mauritius Owl	EX	Mascarenes	1859
	Sceloglaux albifacies	Laughing Owl	EX	New Zealand	1970
Trochilidae	*Chlorostilbon bracei*	Brace's Emerald	EX	Bahamas	1900
	Chlorostilbon elegans	Gould's Emerald	EX	Jamaica & Bahamas	1900
Upupidae	†*Upupa antaois*	St Helena Hoopoe	EX	St Helena	1550
Acanthisittidae	*Xenicus longipes*	Bush Wren	EX	New Zealand	1972
	Xenicus lyalli	Stephens Island Wren	EX	New Zealand	1900
Turdinae	*Myadestes oahensis*	'Amaui	EX	Hawaiian Islands	1825
	Turdus ravidus	Grand Cayman Thrush	EX	Cayman Islands	1938
	Zoothera terrestris	Bonin Thrush	EX	Bonin Islands	1889
Sylviinae	*Bowdleria rufescens*	Chatham Island Fernbird	EX	Chatham Islands	1900
	Nesillas aldabrana	Aldabra Warbler	EX	Seychelles	1983
Malurinae	*Gerygone insularis*	Lord Howe Gerygone	EX	Lord Howe Island	1936
Monarchinae	*Myiagra freycineti*	Guam Flycatcher	EX	Guam	1983
	Pomarea pomarea	Maupiti Monarch	EX	Society Islands	1850
Pachycephalinae	*Turnagra capensis*	South Island Piopio	EX	New Zealand	1963
	Turnagra tanagra	North Island Piopio	EX	New Zealand	1955
Zosteropidae	*Zosterops strenuus*	Robust White-eye	EX	Lord Howe Island	1928
Meliphagidae	*Anthornis melanocephala*	Chatham Island Bellbird	EX	Chatham Islands	1906
	Chaetoptila angustipluma	Kioea	EX	Hawaiian Islands	1900
	Moho apicalis	O'ahu 'O'o	EX	Hawaiian Islands	1850
	Moho bishopi	Bishop's 'O'o	EX	Hawaiian Islands	1981
	Moho braccatus	Kaua'i 'O'o	EX	Hawaiian Islands	1987
	Moho nobilis	Hawai'i 'O'o	EX	Hawaiian Islands	1934
Drepanididae	*Akialoa ellisiana*	O'ahu 'Akialoa	EX	Hawaiian Islands	1940
	Akialoa lanaiensis	Maui Nui 'Akialoa	EX	Hawaiian Islands	1900
	Akialoa obscura	'Akialoa	EX	Hawaiian Islands	1940
	Akialoa stejnegeri	Kaua'i 'Akialoa	EX	Hawaiian Islands	1969
	Ciridops anna	Ula-'ai-hawane	EX	Hawaiian Islands	1937
	Drepanis funerea	Black Mamo	EX	Hawaiian Islands	1907
	Drepanis pacifica	Hawai'i Mamo	EX	Hawaiian Islands	1898
	Dysmorodrepanis munroi	Lana'i Hookbill	EX	Hawaiian Islands	1920
	Paroreomyza flammea	Kakawahie	EX	Hawaiian Islands	1963
	Psittirostra kona	Kona Grosbeak	EX	Hawaiian Islands	1894
	Rhodacanthis flaviceps	Lesser Koa-finch	EX	Hawaiian Islands	1891
	Rhodacanthis palmeri	Greater Koa-finch	EX	Hawaiian Islands	1896
	Viridonia sagittirostris	Greater 'Amakihi	EX	Hawaiian Islands	1901
Icteridae	*Quiscalus palustris*	Slender-billed Grackle	EX	Mexico	1910
Fringillidae	*Chaunoproctus ferreorostris*	Bonin Grosbeak	EX	Bonin Islands	1900
Sturnidae	*Aplonis corvina*	Kosrae Starling	EX	Caroline Islands	1880
	Aplonis fusca	Norfolk Starling	EX	Norfolk Islands	1923
	Aplonis mavornata	Mysterious Starling	EX	Cook Islands	1825
	Fregilupus varius	Réunion Starling	EX	Mascarenes	1860
	†*Necropsar rodericanus*	Rodrigues Starling	EX	Mascarenes	1726
Callaeidae	*Heteralocha acutirostris*	Huia	EX	New Zealand	1907

Part B. A proposed list of endangered bird species for collections inventories and catalogues. In this tabulation, basic information on range—sometimes very generalised—is added for convenience, as given in BirdLife International (2000), but largely excluding countries from which the species in question has (or is thought to have) become extinct. Asterisked (*) entries indicate additions to the BirdLife database since publication.

Family	Scientific Name	Common Name	Red List Category	Range
Tinamidae	*Crypturellus saltuarius*	Magdalena Tinamou	CR	Colombia
	Nothoprocta kalinowskii	Kalinowski's Tinamou	CR	Peru
Podicipedidae	**Rollandia microptera*	Titicaca Flightless Grebe	EN	Peru
	Tachybaptus rufolavatus	Alaotra Grebe	CR	Madagascar
	Podiceps taczanowskii	Junín Grebe	CR	Peru
Diomedeidae	*Diomedea amsterdamensis*	Amsterdam Albatross	CR	Amsterdam Island
	Phoebastria albatrus	Short-tailed Albatross	VU	Japan
	Thalassarche eremita	Chatham Albatross	CR	New Zealand
Procellariidae	*Pseudobulweria aterrima*	Mascarene Black Petrel	CR	Mascarenes
	Pseudobulweria becki	Beck's Petrel	CR	Papua New Guinea, Solomon Islands
	Pseudobulweria macgillivrayi	Fiji Petrel	CR	Fiji
	Pterodroma axillaris	Chatham Petrel	CR	Chatham Islands
	Pterodroma magentae	Chatham Island Taiko	CR	Chatham Islands
	Pterodroma madeira	Zino's Petrel	CR	Madeira
	Pterodroma cahow	Bermuda Petrel	EN	Bermuda
	Pterodroma caribbaea	Jamaica Petrel	CR	Jamaica
	Procellaria conspicillata	Spectacled Petrel	CR	Tristan da Cunha
	Puffinus auricularis	Townsend's Shearwater	CR	Revillagigedo Islands
	Puffinus heinrothi	Heinroth's Shearwater	VU	Papua New Guinea, Solomon Islands
Hydrobatidae	*Oceanodroma macrodactyla*	Guadalupe Storm Petrel	CR	Guadalupe (Mexico)
Sulidae	*Papasula abbotti*	Abbott's Booby	CR	Christmas Island (Australia)
Phalacorcoracidae	*Phalacrocorax harrisi*	Galápagos Cormorant	EN	Galapagos Islands
	Phalacrocorax carunculatus	New Zealand King Shag	VU	New Zealand
Fregatidae	*Fregata andrewsi*	Christmas Island Frigatebird	CR	Christmas Island (Australia)
Ardeidae	*Ardea insignis*	White-bellied Heron	EN	Bhutan, India, Bangladesh, Myanmar
	Gorsachius magnificus	White-eared Night Heron	EN	China
	Gorsachius goisagi	Japanese Night-heron	EN	Japan, Philippines
Ciconiidae	*Ciconia stormi*	Storm's Stork	EN	Malaysia, Indonesia
	Leptoptilos dubius	Greater Adjutant	EN	India, Cambodia
Threskiornithidae	*Bostrychia bocagei*	Dwarf Olive Ibis	CR	São Tomé
	Geronticus eremita	Northern Bald Ibis	CR	Morocco, Middle East
	Pseudibis davisoni	White-shouldered Ibis	CR	South-East Asia
	Thaumatibis gigantea	Giant Ibis	CR	Cambodia, Thailand, Vietnam
	Nipponia nippon	Crested Ibis	EN	China
	Platalea minor	Black-faced Spoonbill	EN	North and South Korea
Anatidae	*Branta sandvicensis*	Hawaiian Goose	VU	Hawaiian Islands
	Tadorna cristata	Crested Shelduck	CR	Russia, South Korea, Japan

	Cairina scutulata	White-winged Duck	EN	NE India to Indochina, Indonesia
	Anas laysanensis	Laysan Duck	VU	Hawaiian Islands
	Anas bernieri	Madagascar Teal	EN	Madagascar
	Anas aucklandica	Auckland Island Teal	VU	Auckland Islands
	Anas nesiotis	Campbell Island Teal	CR	Campbell Islands
	Rhodonessa caryophyllacea	Pink-headed Duck	CR	North-east India, Bangladesh
	Aythya innotata	Madagascar Pochard	CR	Madagascar
	Mergus octosetaceus	Brazilian Merganser	CR	Brazil, Argentina
Cathartidae	*Gymnogyps californianus*	California Condor	CR	USA
Accipitridae	*Leptodon forbesi*	White-collared Kite	CR	Brazil
	Chondrohierax wilsonii	Cuban Kite	CR	Cuba
	Haliaeetus sanfordi	Sanford's Fish Eagle	VU	Papua New Guinea, Solomon Islands
	Haliaeetus vociferoides	Madagascar Fish Eagle	CR	Madagascar
	Eutriorchis astur	Madagascar Serpent Eagle	CR	Madagascar
	Circus maillardi	Réunion Harrier	EN	Mascarenes
	Circus maurus	Black Harrier	VU	Southern Africa
	Accipiter imitator	Imitator Sparrowhawk	VU	Papua New Guinea, Solomon Islands
	Accipiter gundlachi	Gundlach's Hawk	EN	Cuba
	Erythrotriorchis radiatus	Red Goshawk	VU	Australia
	Leucopternis occidentalis	Grey-backed Hawk	EN	Ecuador, Peru
	Buteo ridgwayi	Ridgway's Hawk	CR	Haiti, Dominican Republic
	Buteo galapagoensis	Galápagos Hawk	VU	Galapagos Islands
	Pithecophaga jefferyi	Philippine Eagle	CR	Philippines
	Aquila adalberti	Spanish Imperial Eagle	VU	Spain
	Spizaetus bartelsi	Javan Hawk Eagle	EN	Indonesia
Falconidae	*Falco punctatus*	Mauritius Kestrel	VU	Mascarenes
	Falco araea	Seychelles Kestrel	VU	Seychelles
Megapodiidae	*Aepypodius bruijnii*	Bruijn's Brush Turkey	VU	Indonesia
	Megapodius pritchardii	Polynesian Megapode	CR	Tonga
Cracidae	*Penelope albipennis*	White-winged Guan	CR	Peru
	Pipile pipile	Trinidad Piping Guan	CR	Trinidad & Tobago
	Mitu mitu	Alagoas Curassow	EW	Brazil
	Crax blumenbachii	Red-billed Curassow	EN	Brazil
Phasianidae	*Francolinus ochropectus*	Djibouti Francolin	CR	Djibouti
	Arborophila rufipectus	Sichuan Partridge	EN	China
	Arborophila davidi	Orange-necked Partridge	EN	Vietnam
	Arborophila cambodiana	Chestnut-headed Partridge	EN	Thailand, Cambodia
	Ophrysia superciliosa	Himalayan Quail	CR	India
	Lophura edwardsi	Edwards's Pheasant	EN	Vietnam
	Odontophorus strophium	Gorgeted Wood Quail	CR	Colombia
Turnicidae	*Turnix olivii*	Buff-breasted Buttonquail	EN	Australia
Gruidae	*Grus americana*	Whooping Crane	EN	Canada, USA
Rallidae	*Sarothrura ayresi*	White-winged Flufftail	EN	Ethiopia, southern Africa
	Sarothrura watersi	Slender-billed Flufftail	EN	Madagascar

	Laterallus levraudi	Rusty-flanked Crake	EN	Venezuela
	Gallirallus lafresnayanus	New Caledonian Rail	CR	New Caledonia
	Gallirallus sylvestris	Lord Howe Woodhen	EN	Lord Howe Island
	Gallirallus owstoni	Guam Rail	EW	Guam
	Rallus wetmorei	Plain-flanked Rail	EN	Venezuela
	Amaurornis olivieri	Sakalava Rail	CR	Madagascar
	Cyanolimnas cerverai	Zapata Rail	EN	Cuba
	Porphyrio hochstetteri	South Island Takahe	EN	New Zealand
	Gallinula pacifica	Samoan Moorhen	CR	Samoa
	Gallinula silvestris	Makira Moorhen	CR	Solomon Islands
Rhynochetidae	*Rhynochetos jubatus*	Kagu	EN	New Caledonia
Otididae	*Ardeotis nigriceps*	Great Indian Bustard	EN	India
	Houbaropsis bengalensis	Bengal Florican	EN	India, Nepal, Cambodia, Vietnam
Haematopodidae	*Haematopus chathamensis*	Chatham Island Oystercatcher	EN	Chatham Islands
Charadriidae	*Charadrius sanctaehelenae*	St Helena Plover	EN	St Helena
	Thinornis novaeseelandiae	Shore Plover	EN	New Zealand
	Vanellus macropterus	Javanese Lapwing	CR	Indonesia
Scolopacidae	*Numenius borealis*	Eskimo Curlew	CR	Canada, USA, Argentina, Brazil, Chile
	Numenius tenuirostris	Slender-billed Curlew	CR	Russia, S Europe, North Africa
	Tringa guttifer	Spotted Greenshank	EN	E Russia, South-East Asia
	Prosobonia cancellata	Tuamotu Sandpiper	EN	Tuamotu Archipelago
Recurvirostridae	*Himantopus novaezelandiae*	Black Stilt	CR	New Zealand
Glareolidae	*Rhinoptilus bitorquatus*	Jerdon's Courser	CR	India
Laridae	*Larus fuliginosus*	Lava Gull	VU	Galapagos Islands
	Sterna bernsteini	Chinese Crested Tern	CR	China, South-East Asia
Columbidae	*Columba thomensis*	Maroon Pigeon	VU	São Tomé
	Columba argentina	Silvery Woodpigeon	CR	Indonesia, Malaysia
	Columba pallidiceps	Yellow-legged Pigeon	EN	Papua New Guinea, Solomon Islands
	Columba mayeri	Pink Pigeon	EN	Mascarenes
	Zenaida graysoni	Socorro Dove	EW	Revillagigedo Islands
	Columbina cyanopis	Blue-eyed Ground Dove	CR	Brazil
	Leptotila wellsi	Grenada Dove	CR	Grenada
	Gallicolumba platenae	Mindoro Bleeding-heart	CR	Philippines
	Gallicolumba keayi	Negros Bleeding-heart	CR	Philippines
	Gallicolumba menagei	Sulu Bleeding-heart	CR	Philippines
	Gallicolumba kubaryi	Caroline Islands Ground Dove	VU	Caroline Islands
	Gallicolumba erythroptera	Polynesian Ground Dove	CR	Society Islands, Tuamotu Archipelago
	Gallicolumba salamonis	Thick-billed Ground Dove	CR	Solomon Islands
	Gallicolumba rubescens	Marquesan Ground Dove	EN	Marquesas Islands
	Phapitreron cinereiceps	Tawitawi Brown Dove	CR	Philippines
	Ptilinopus rarotongensis	Cook Islands Fruit Dove	VU	Cook Islands
	Ptilinopus huttoni	Rapa Fruit Dove	VU	Tubuai Islands

	Ptilinopus chalcurus	Makatea Fruit Dove	VU	Tuamotu Archipelago
	Ptilinopus arcanus	Negros Fruit Dove	CR	Philippines
	Ducula aurorae	Polynesian Imperial Pigeon	EN	Tahiti
	Ducula galeata	Marquesan Imperial Pigeon	CR	Marquesas Islands
	Ducula whartoni	Christmas Island Imperial Pigeon	CR	Christmas Island (Australia)
Psittacidae	*Charmosyna toxopei*	Blue-fronted Lorikeet	CR	Indonesia
	Charmosyna diadema	New Caledonian Lorikeet	CR	New Caledonia
	Prioniturus verticalis	Blue-winged Racquet-tail	EN	Philippines
	Cyanoramphus cookii	Norfolk Island Green Parrot	EN	Norfolk Island
	Cyanoramphus forbesi	Forbes's Parakeet	EN	Chatham Islands
	Cyanoramphus malherbi	Orange-fronted Parakeet	EN	New Zealand
	Eunymphicus uvaeensis	Uvea Parakeet	EN	New Caledonia
	Neophema chrysogaster	Orange-bellied Parrot	CR	Australia
	Geopsittacus occidentalis	Night Parrot	CR	Australia
	Strigops habroptilus	Kakapo	CR	New Zealand
	Psittacula eques	Mauritius Parakeet	CR	Mascarenes
	Anodorhynchus leari	Lear's Macaw	CR	Brazil
	Anodorhynchus glaucus	Glaucous Macaw	CR	Argentina, Paraguay, Uruguay, Brazil
	Cyanopsitta spixii	Spix's Macaw	CR	Brazil
	Ara glaucogularis	Blue-throated Macaw	CR	Bolivia
	Aratinga brevipes	Socorro Parakeet	EN	Revillagigedo Islands
	Ognorhynchus icterotis	Yellow-eared Parrot	CR	Colombia, Ecuador
	Forpus xanthops	Yellow-faced Parrotlet	VU	Peru
	Hapalopsittaca amazonina	Rusty-faced Parrot	EN	Venezuela, Colombia
	Hapalopsittaca fuertesi	Fuertes's Parrot	CR	Colombia
	Amazona vittata	Puerto Rican Amazon	CR	Puerto Rico
	Amazona rhodocorytha	Red-browed Amazon	EN	Brazil
	Amazona versicolor	St Lucia Amazon	VU	St Lucia
	Amazona arausiaca	Red-necked Amazon	VU	Dominica
	Amazona guildingii	St Vincent Amazon	VU	St Vincent
	Amazona imperialis	Imperial Amazon	EN	Dominica
Cuculidae	*Carpococcyx viridis*	Sumatran Ground Cuckoo	CR	Indonesia
	Centropus steerii	Black-hooded Coucal	CR	Philippines
	Coccyzus ferrugineus	Cocos Cuckoo	VU	Cocos Island (Mexico)
Tytonidae	*Tyto nigrobrunnea*	Taliabu Masked Owl	EN	Indonesia
Strigidae	*Otus siaoensis*	Siau Scops Owl	CR	Indonesia
	Otus hartlaubi	São Tomé Scops Owl	VU	São Tomé
	Otus insularis	Seychelles Scops Owl	CR	Seychelles
	Otus capnodes	Anjouan Scops Owl	CR	Comoro Islands
	Otus moheliensis	Moheli Scops Owl	CR	Comoro Islands
	Otus pauliani	Grand Comoro Scops Owl	CR	Comoro Islands
	Ketupa blakistoni	Blakiston's Fish Owl	EN	Russia, China, Japan
	Xenoglaux loweryi	Long-whiskered Owlet	EN	Peru
	Heteroglaux blewitti	Forest Owlet	CR	India
	Ninox ios	Cinnabar Hawk Owl	VU	Indonesia
Aegothelidae	*Aegotheles savesi*	New Caledonian Owlet-nightjar	CR	New Caledonia

Caprimulgidae	*Siphonorhis americanus*	Jamaican Pauraque	CR	Jamaica
	Caprimulgus noctitherus	Puerto Rican Nightjar	CR	Puerto Rico
	Caprimulgus candicans	White-winged Nightjar	EN	Brazil, Paraguay, Bolivia
	Caprimulgus solala	Nechisar Nightjar	VU	Ethiopia
Apodidae	*Collocalia sawtelli*	Atiu Swiftlet	VU	Cook Islands
	Collocalia leucophaeus	Tahiti Swiftlet	VU	Tahiti
	Apus acuticauda	Dark-rumped Swift	VU	Bhutan, India
Trochilidae	*Glaucis dohrnii*	Hook-billed Hermit	EN	Brazil
	Lophornis brachylopha	Short-crested Coquette	CR	Mexico
	Lepidopyga lilliae	Sapphire-bellied Hummingbird	CR	Colombia
	Amazilia luciae	Honduran Emerald	CR	Honduras
	Amazilia castaneiventris	Chestnut-bellied Hummingbird	CR	Colombia
	Aglaeactis aliciae	Purple-backed Sunbeam	VU	Peru
	Sephanoides fernandensis	Juan Fernández Firecrown	CR	Juan Fernández Island
	Heliangelus zusii	Bogotá Sunangel	CR	Colombia
	Eriocnemis nigrivestis	Black-breasted Puffleg	CR	Ecuador
	Eriocnemis godini	Turquoise-throated Puffleg	CR	Ecuador
	Eriocnemis mirabilis	Colourful Puffleg	CR	Colombia
	Taphrolesbia griseiventris	Grey-bellied Comet	EN	Peru
	Loddigesia mirabilis	Marvellous Spatuletail	EN	Peru
	Selasphorus ardens	Glow-throated Hummingbird	VU	Panama
Alcedinidae	*Todiramphus ruficollaris*	Mangaia Kingfisher	VU	Cook Islands
	Todiramphus godeffroyi	Marquesan Kingfisher	EN	Marquesas Islands
	Todiramphus gambieri	Tuamotu Kingfisher	VU	Tuamotu Archipelago
	Actenoides bougainvillei	Moustached Kingfisher	VU	Papua New Guinea, Solomon Islands
Bucerotidae	*Anthracoceros montani*	Sulu Hornbill	CR	Philippines
	Penelopides mindorensis	Mindoro Tarictic	EN	Philippines
	Aceros waldeni	Visayan Wrinkled Hornbill	CR	Philippines
	Aceros narcondami	Narcondam Hornbill	VU	Andaman Islands
Galbulidae	*Jacamaralcyon tridactyla*	Three-toed Jacamar	EN	Brazil
Capitonidae	**Capito wallacei*	Scarlet-banded Barbet	VU	Peru
Picidae	*Colaptes fernandinae*	Fernandina's Flicker	EN	Cuba
	Campephilus imperialis	Imperial Woodpecker	CR	Mexico
	Campephilus principalis	Ivory-billed Woodpecker	CR	Cuba, USA
	Sapheopipo noguchii	Okinawa Woodpecker	CR	Japan
Furnariidae	*Cinclodes aricomae*	Royal Cinclodes	CR	Peru, Bolivia
	Cinclodes palliatus	White-bellied Cinclodes	VU	Peru
	Aphrastura masafuerae	Masafuera Rayadito	VU	Juan Fernández Island
	Leptasthenura xenothorax	White-browed Tit Spinetail	EN	Peru
	Synallaxis courseni	Apurímac Spinetail	VU	Peru
	Synallaxis infuscata	Plain Spinetail	CR	Brazil
	Synallaxis kollari	Hoary-throated Spinetail	EN	Brazil
	Philydor novaesi	Alagoas Foliage-gleaner	CR	Brazil
Formicariidae	*Clytoctantes atrogularis*	Rondônia Bushbird	CR	Brazil
	Myrmotherula snowi	Alagoas Antwren	CR	Brazil
	Myrmotherula fluminensis	Rio de Janeiro Antwren	CR	Brazil

	Herpsilochmus parkeri	Ash-throated Antwren	EN	Bolivia
	Formicivora littoralis	Restinga Antwren	EN	Brazil
	Pyriglena atra	Fringe-backed Fire-eye	CR	Brazil
	Grallaria chthonia	Táchira Antpitta	EN	Venezuela
	Grallaria ridgelyi	Jocotoco Antpitta	EN	Ecuador
	Grallaria milleri	Brown-banded Antpitta	EN	Colombia
	Grallaricula ochraceifrons	Ochre-fronted Antpitta	EN	Peru
Rhinocryptidae	*Merulaxis stresemanni*	Stresemann's Bristlefront	CR	Brazil
	Scytalopus iraiensis	Tall-grass Wetland Tapaculo	EN	Brazil
	Scytalopus psychopompus	Bahia Tapaculo	CR	Brazil
Cotingidae	*Calyptura cristata*	Kinglet Calyptura	CR	Brazil
	Cotinga maculata	Banded Cotinga	EN	Brazil
Pipridae	*Antilophia bokermanni*	Araripe Manakin	CR	Brazil
Tyrannidae	*Elaenia ridleyana*	Noronha Elaenia	VU	Fernando de Noronha
	Anairetes alpinus	Ash-breasted Tit Tyrant	EN	Peru, Bolivia
	Phylloscartes roquettei	Minas Gerais Tyrannulet	CR	Brazil
	Phylloscartes ceciliae	Alagoas Tyrannulet	CR	Brazil
	Tyrannus cubensis	Giant Kingbird	EN	Cuba
Phytotomidae	*Phytotoma raimondii*	Peruvian Plantcutter	EN	Peru
Pittidae	*Pitta gurneyi*	Gurney's Pitta	CR	Thailand
	Pitta superba	Superb Pitta	VU	Manus (Papua New Guinea)
	Pitta anerythra	Black-faced Pitta	VU	Papua New Guinea, Solomon Islands
Alaudidae	*Mirafra degodiensis*	Degodi Lark	VU	Ethiopia
	Heteromirafra archeri	Archer's Lark	VU	Somalia
	Alauda razae	Raso Lark	CR	Cape Verde Islands
Hirundinidae	*Eurochelidon sirintarae*	White-eyed River Martin	CR	Thailand
Campephagidae	*Coracina typica*	Mauritius Cuckoo Shrike	VU	Mascarenes
	Coracina newtoni	Réunion Cuckoo Shrike	EN	Mascarenes
Pycnonotidae	*Phyllastrephus leucolepis*	Liberian Greenbul	CR	Liberia
	Hypsipetes olivaceus	Mauritius Bulbul	VU	Mascarenes
Laniidae	*Lanius newtoni*	São Tomé Fiscal	CR	São Tomé
	Laniarius brauni	Orange-breasted Bush Shrike	EN	Angola
	Laniarius amboimensis	Gabela Bush Shrike	EN	Angola
	Laniarius liberatus	Bulo Burti Boubou	CR	Somalia
	Telophorus kupeensis	Mount Kupe Bush Shrike	EN	Cameroon
	Malaconotus alius	Uluguru Bush-shrike	EN	Tanzania
Vangidae	*Calicalicus rufocarpalis*	Red-shouldered Vanga	VU	Madagascar
Troglodytidae	*Thryothorus nicefori*	Niceforo's Wren	CR	Colombia
	Troglodytes tanneri	Clarión Wren	VU	Revillagigedo Islands
Mimidae	*Nesomimus trifasciatus*	Floreana Mockingbird	EN	Galapagos Islands
	Mimodes graysoni	Socorro Mockingbird	CR	Revillagigedo Islands
	Toxostoma guttatum	Cozumel Thrasher	CR	Cozumel (Mexico)
	Ramphocinclus brachyurus	White-breasted Thrasher	EN	Martinique, St Lucia
Turdinae	*Zoothera major*	Amami Thrush	CR	Japan
	Zoothera turipavae	Guadalcanal Thrush	VU	Solomon Islands
	Myadestes myadestinus	Kama'o	CR	Hawaiian Islands

	Myadestes lanaiensis	Oloma'o	CR	Hawaiian Islands
	Myadestes palmeri	Puaiohi	CR	Hawaiian Islands
	Turdus helleri	Taita Thrush	CR	Kenya
	Copsychus sechellarum	Seychelles Magpie Robin	CR	Seychelles
Timaliinae	*Malacocincla perspicillata*	Black-browed Babbler	VU	Indonesia
Sylviinae	*Apalis fuscigularis*	Taita Apalis	CR	Kenya
	Bradypterus grandis	Dja River Warbler	VU	Cameroon, Gabon, Central African Rep.
	Acrocephalus familiaris	Millerbird	CR	Hawaiian Islands
	Acrocephalus caffer	Tahiti Reed Warbler	VU	Society Islands
	Acrocephalus rodericanus	Rodrigues Warbler	EN	Mascarenes
	Orthotomus moreaui	Long-billed Tailorbird	CR	Tanzania, Mozambique
	Macrosphenus pulitzeri	Pulitzer's Longbill	EN	Angola
	Amaurocichla bocagii	São Tomé Short-tail	VU	São Tomé
	Phylloscopus amoenus	Sombre Leaf Warbler	VU	Solomon Islands
Muscicapinae	*Petroica traversi*	Black Robin	EN	Chatham Islands
	Cyornis ruckii	Rueck's Blue Flycatcher	CR	Indonesia
Monarchinae	*Eutrichomyias rowleyi*	Caerulean Paradise Flycatcher	CR	Indonesia
	Terpsiphone smithii	Annobón Paradise Flycatcher	VU	Annobón
	Terpsiphone corvina	Seychelles Paradise Flycatcher	CR	Seychelles
	Pomarea dimidiata	Rarotonga Monarch	EN	Cook Islands
	Pomarea nigra	Tahiti Monarch	CR	Society Islands
	Pomarea mendozae	Marquesan Monarch	EN	Marquesas Islands
	Pomarea whitneyi	Fatuhiva Monarch	CR	Marquesas Islands
	Monarcha boanensis	Black-chinned Monarch	CR	Indonesia
Rhipidurinae	*Rhipidura malaitae*	Malaita Fantail	VU	Solomon Islands
	Colluricincla sanghirensis	Sangihe Shrike-thrush	CR	Indonesia
Dicaeidae	*Dicaeum quadricolor*	Cebu Flowerpecker	CR	Philippines
Nectariniidae	*Nectarinia thomensis*	Giant Sunbird	VU	São Tomé
	Nectarinia rockefelleri	Rockefeller's Sunbird	VU	Democratic Rep. of Congo
Zosteropidae	*Zosterops ficedulinus*	São Tomé White-eye	VU	São Tomé
	Zosterops chloronothos	Mauritius Olive White-eye	EN	Mascarenes
	Zosterops modestus	Seychelles White-eye	CR	Seychelles
	Zosterops rotensis	Rota Bridled White-eye	CR	North Marianas
	Zosterops nehrkorni	Sangihe White-eye	CR	Indonesia
	Zosterops albogularis	White-chested White-eye	CR	Norfolk Island
	Rukia ruki	Faichuk White-eye	CR	Faichuk group (Chuuk) in F.S.Micronesia
Meliphagidae	*Notiomystis cincta*	Stitchbird	VU	New Zealand
	Manorina melanotis	Black-eared Miner	EN	Australia
Emberizinae	*Junco insularis*	Guadalupe Junco	CR	Guadalupe (Mexico)
	Spizella wortheni	Worthen's Sparrow	EN	Mexico
	Torreornis inexpectata	Cuban Sparrow	EN	Cuba
	Atlapetes flaviceps	Yellow-headed Brush Finch	EN	Colombia
	Atlapetes pallidiceps	Pale-headed Brush Finch	CR	Ecuador
	Nesospiza wilkinsi	Grosbeak Bunting	VU	Tristan da Cunha
	Poospiza garleppi	Cochabamba Mountain Finch	EN	Bolivia

	Sporophila melanops	Hooded Seedeater	CR	Brazil
	Sporophila nigrorufa	Black-and-tawny Seedeater	VU	Bolivia, Brazil
	Sporophila zelichi	Entre Ríos Seedeater	CR	Argentina, Paraguay
	Sporophila insulata	Tumaco Seedeater	CR	Colombia
	Melanospiza richardsoni	St Lucia Black Finch	EN	St Lucia
	Camarhynchus heliobates	Mangrove Finch	CR	Galapagos Islands
Thraupinae	*Conothraupis mesoleuca*	Cone-billed Tanager	CR	Brazil
	Nemosia rourei	Cherry-throated Tanager	CR	Brazil
Parulidae	*Vermivora bachmanii*	Bachman's Warbler	CR	USA, Cuba
	Dendroica angelae	Elfin-woods Warbler	VU	Puerto Rico
	Geothlypis beldingi	Belding's Yellowthroat	CR	Mexico
	Leucopeza semperi	Semper's Warbler	CR	St Lucia
Drepanididae	*Telespiza ultima*	Nihoa Finch	CR	Hawaiian Islands
	Psittirostra psittacea	'O'u	CR	Hawaiian Islands
	Pseudonestor xanthophrys	Maui Parrotbill	VU	Hawaiian Islands
	Hemignathus lucidus	Nukupu'u	CR	Hawaiian Islands
	Oreomystis bairdi	'Akikiki	CR	Hawaiian Islands
	Paroreomyza maculata	O'ahu 'Alauahio	CR	Hawaiian Islands
	Melamprosops phaeosoma	Po'o-uli	CR	Hawaiian Islands
Vireonidae	*Vireo caribaeus*	San Andrés Vireo	CR	San Andrés (Colombia)
Icteridae	*Icterus oberi*	Montserrat Oriole	CR	Montserrat
	Curaeus forbesi	Forbes's Blackbird	CR	Brazil
	Macroagelaius subalaris	Mountain Grackle	CR	Colombia
Fringillidae	*Serinus flavigula*	Yellow-throated Serin	VU	Ethiopia
	Neospiza concolor	São Tomé Grosbeak	CR	São Tomé
	Carduelis cucullata	Red Siskin	EN	Venezuela, Colombia
	Carduelis johannis	Warsangli Linnet	EN	Somalia
	Loxia megaplaga	Hispaniolan Crossbill	EN	Haiti, Dominican Republic
	Pyrrhula murina	Azores Bullfinch	EN	Azores
Estrilidae	*Estrilda poliopareia*	Anambra Waxbill	VU	Nigeria
	Erythrura kleinschmidti	Pink-billed Parrotfinch	EN	Fiji
Ploceinae	*Ploceus aureonucha*	Golden-naped Weaver	EN	Democratic Rep. of Congo
	Malimbus ibadanensis	Ibadan Malimbe	EN	Nigeria
	Foudia rubra	Mauritius Fody	CR	Mascarenes
	Foudia flavicans	Rodrigues Fody	VU	Mascarenes
Sturnidae	*Aplonis santovestris*	Santo Mountain Starling	VU	Vanuatu
	Aplonis pelzelni	Pohnpei Mountain Starling	CR	Pohnpei
	Aplonis cinerascens	Rarotonga Starling	VU	Cook Islands
	Leucopsar rothschildi	Bali Starling	CR	Indonesia
Oriolidae	*Oriolus crassirostris*	São Tomé Oriole	VU	São Tomé
Dicruridae	*Dicrurus fuscipennis*	Grand Comoro Drongo	EN	Comoro Islands
	Dicrurus waldenii	Mayotte Drongo	EN	Comoro Islands
Callaeidae	*Callaeas cinerea*	Kokako	EN	New Zealand
Corvidae	*Corvus unicolor*	Banggai Crow	EN	Indonesia
	Corvus kubaryi	Mariana Crow	EN	North Mariana Islands
	Corvus hawaiiensis	Hawaiian Crow	CR	Hawaiian Islands

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Why museums matter: report from the workshops 14-15 November 1999 'Increased cooperation between bird collections'

by Joanne H. Cooper & Frank D. Steinheimer

The post-conference workshops were primarily aimed at museum workers directly involved in curation and collections management, and were attended by about 85 delegates from more than 50 institutions in 22 countries. As originally intended, the main theme of the workshops was increased cooperation between bird collections, particularly within Europe, but as with the main meeting this was often overlain with a far more global perspective. Four sessions were spread over two days, with a largely free-form structure allowing wide-ranging and flexible discussions of issues raised in the foregoing conference or during the workshops themselves. Rather than consider each session individually, this report aims to provide an overview of the workshops as a whole, and is based around the key subjects that emerged.

Increasing cooperation

The value of cooperation and collaboration was emphasised throughout the conference and a definite eagerness for developing greater cooperative links both at European and global levels was clearly demonstrated during the workshops. Fundamental to achieving this aim is communication, and the basic currency of communication is information. At its core, this information begins simply as resources, places and people: what, where, who? An important step in compiling and disseminating such basic information is the directory presented by Kees Roselaar in this volume (Roselaar 2003), unveiled at the workshops. This directory is based mainly on the responses of curators to a questionnaire about their collections, combined with previously published data. Initially, Roselaar intended to contact only collections with over 20,000 bird specimens, but as many smaller collections hold valuable material in the form of types or extinct species, they too made it into the list. However, as a printed publication, the scope of the directory was inevitably constrained, but there was some enthusiasm for developing a version of it on the internet. Potentially, institutions would be able to update their entries directly, and size limits would be effectively removed, allowing any institution with a bird collection to add to it—even school collections, which might contain country or county records (see Hudecek *et al.* 1999). Recognising this, a new project group, 'Museums Ornithology', has been established with the German Ornithologists' Society with the aim of compiling the data of even the tiniest bird collections in Germany.

Means of making and maintaining contact were also considered. Apart from the diversity of the conference and workshop delegates, and the resulting opportunities for networking (Cooper 2000), another valuable quality was the meeting's largely informal nature, which positively encouraged contact. As such meetings have until this event been relatively infrequent occurrences, there is both a niche and a need for alternative, ongoing means of contact. To this end, e-mail forums were discussed and met with considerable interest. A US-based bird collections forum exists in the form of AVECOL, used primarily by curators. However, it was felt that a new European-based forum would be appropriate and useful, and the task of creating one was undertaken by Jörn Scharlemann with the assistance of Chris Sleep and James Van Remsen. Hosted by The Natural History Museum, London (BMNH), the electronic Bulletin for European Avian Curators (eBEAC) is now fully functioning (see below, under 'eBEAC', for further information).

The basic foundations for increasing cooperation seem to have been successfully laid. However, as of August 2002, relatively few messages had been sent on eBEAC and there is little ongoing discussion using this new forum. The trick now must be to maintain the momentum gathered during the workshops and build upon it.

Inventories

Discussions surrounding Roselaar's list and its presentation of broad collections statistics developed to encompass the possibilities of more detailed international collections inventories, catalogues or databases and their cooperative compilation, aiming ultimately at publication on the internet. It was generally agreed that an inventory project of some kind would be an excellent practical expression of the cooperation that the conference and workshops were hoping to foster.

Specifically, discussion concentrated on two forms of catalogue/database, (1) types and (2) extinct and endangered (E&E), both of which were considered to have their advantages and disadvantages as potential projects.

As the basic defining units of biodiversity, type specimens carry a greater systematic importance than E&E material, and so should arguably take priority. Additionally, it was pointed out that the world type list is considerably more static than the world list of E&E birds, which is unfortunately steadily increasing. However, assembling a type catalogue even for an individual collection is not an easy task, given the taxonomic complications this can involve, for example in synonymies. However, to an extent, a type catalogue would be self-correcting as information accumulated and could in fact open up discussion between institutions, probably providing fresh insights into specimens' status.

Rémy Bruckert, Muséum National d'Histoire Naturelle (MNHN), in cooperation with the Natural History Museum (NHM), American Museum of Natural History (AMNH), Edward Dickinson and Norbert Bahr, has now taken on this challenge and is preparing a type- and taxonomical database to house the world's digital avian type catalogue (Bruckert in press). Obviously a great help in amassing such an amount of data is the fact that several institutions already have published type catalogues available, covering some of the largest type collections in the world, amalgamation of which has proved to be an excellent foundation for this project.

Fewer institutions have an E&E catalogue available, although it emerged that a limited attempt at a European E&E online database has been made, based on data from eight collections around Europe. This is the Extinct and Vanishing Animals Project (EVAP), coordinated by Professor Marco Vannini of the Zoological Museum of the University of Florence using EU funding (see 'Websites' for address). Whilst a separate project is probably appropriate, EVAP does give ideas upon which to build.

A fundamental starting point for devising any E&E catalogue is a species list. The Bird Group at NHM, in consultation with BirdLife International, have drawn up such a list, based on the recently published landmark volume *Threatened birds of the world* (BirdLife International 2000) (Adams *et al.* 2003, this volume). It is hoped that initially this list will be of assistance to institutions wishing to collate their own E&E catalogues, with the compilation of worldwide databases a longer-term prospect.

The talks surrounding the assembly and publication of inventories raised a number of issues that any similar project will be likely to face. After the complexities associated with compilation, a particular concern is maintenance: how should such inventories be kept updated? Enthusiasm for the principle of global inventories was considerable but at times guarded as the scale of the logistics involved became apparent. It must be said that there is considerable responsibility in taking on such a task, and concerns such as the availability of personnel and their time and, inevitably, funding must be acknowledged and addressed. Each institution that becomes involved will have to face these issues, but especially those contemplating the initial steps of creating their individual E&E or type catalogues, possibly from scratch.

Collections and curation

These workshops were not a forum for questioning whether or not to collect birds (for which see Remsen 1995, Collar 2000); rather they were used to examine how collecting, particularly within Europe, could or should be carried out in the future. Active collecting is now pursued mainly by North American institutions; only a very few European museums are able to carry out some collecting, and little of that is of their own national avifauna. Arguably, the most important impact this decline has on collections is the significant gaps that are opening up in specimen time-series, which not only has implications for long-term studies (e.g. Green & Scharlemann 2003, this issue), but also affects interpretation of other data, such as distribution patterns.

Whilst it would be possible for curators in non-collecting institutions to gain experience of collecting through participating in expeditions run by collecting institutions, this does not address the key problem of time gaps in European avifaunas or the obstacles of public opposition. There appeared to be a groundswell of opinion at the workshops that it is perhaps time to broach these issues with government and conservation bodies.

For institutions wishing to add objectively to their collections, in addition to more opportunistic sources such as donation, specimen exchanges with other collections can be extremely valuable. Exchanges are commonly based on unprepared frozen material, and can be especially useful for acquiring anatomical specimens, which are regaining recognition as key material for taxonomic research (Livezey 2003 and Olson 2003, this issue). Institutions that may not maintain anatomical collections should be aware that specimens they might normally discard could be of considerable interest to somewhere else. Another part of the appeal and strength of exchanges is that almost any specimen may be of value to the right collection. One institution's common birds are often another's rarities, so if facilities allow it can be worth retaining material specifically with exchanges in mind. Freezer inventories are generally a fundamental starting point in setting up exchanges; after that it is a question of communication, and it has been found that email forums can be effective for this.

There is a perceived decline in preparation skills and expertise, possibly linked to the decline in collecting but probably also owing to staffing reductions and perhaps to the fact that workers may not be well-placed to gain experience of new or unfamiliar methods. Increasingly, there is more emphasis on multi-preparations, where parts of a single specimen are preserved in several different ways, which can be as simple as preserving a spread wing on a skin specimen. Additionally, the value of incidental material associated with specimens, such as stomach contents, frozen tissue samples, avian parasites or even sound recordings (see Alström & Ranft 2003, this issue), is gaining recognition and can build into an impressive research resource. It was felt that technical manuals, including videos, would be very welcome, and that some form of preparation workshop might be appropriate at subsequent meetings.

Another point of discussion was the increasing numbers of DNA sampling requests for museum specimens. It seems that relatively few institutions have a set policy governing destructive sampling but, as techniques develop not only for DNA but also for chemical sampling or anatomical analyses, such protocols will be essential to protect collections. As an example, the destructive sampling protocol of the Division of Birds, National Museum of Natural History (USNM), Smithsonian, is available online (for addresses, see below).

Going global

A subject frequently returned to throughout the conference and workshops was information technology and its huge potential as a means of disseminating and analysing collections data. This summary is not the place to attempt a detailed review of the complex, and occasionally controversial, discussions that developed, but it is abundantly clear that the opportunities presented by the internet and other information technology are impressive to say the least, culminating in the concept of a virtual world museum (see, e.g., Peterson *et al.* 2003). However, tools this powerful must be handled with extreme care and it must be said that the opportunities are not necessarily all positive. Basic issues surrounding the mass release of data, particularly in catalogues or inventories, that emerged in the course of the workshops included:

funding of data capture/publication and subsequent charging; intellectual rights of institutions to their collections data and continued control of them; rights of the specimen's nation of origin to the data; implications of an increasing perception (rightly or wrongly) of specimens as economic property (see Graves 2000 for more). Once data have been released, the consensus is that it may be difficult to backtrack and reclaim them in the future. If this is so, then decisions taken now must be made very carefully and projects such as the type and E&E catalogues may well prove to be important testing grounds.

The future?

As the first meeting of their kind the workshops were rated a success, achieving their aim of opening up new lines of communication between workers in bird collections and encouraging new levels of cooperation. Suggestions for increasing cooperation, such as the creation of eBEAC, were met with enthusiasm, with the overall verdict that yes, we want more interaction, and future workshops of a similar nature should take place. The Second European Symposium 'Bird Collections in Europe: The Challenges of Mutual Cooperation' has now been held, from 9 to 12 November 2001 in Bonn, Germany, and was also well attended. The Alexander Koenig Research Institute and Zoological Museum (ZFMK), Bonn, invited speakers for lectures covering bird collections and biodiversity, the promotion of ornithological science, sharing databases, the history and development of individual collections and other topics. Detailed proceedings of this second conference will be published in due course (Rheinwald in press).

However, these meetings will come but once a year at most, and nurturing our new cooperative opportunities will need more attention than that. Continuing the process begun at these workshops needs input from individual workers, whether sitting on steering committees, initiating specimen exchanges or simply posting a message on eBEAC. We have started something at these conferences and workshops—now let us see how far we can take it.

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Extinct and Vanishing Animals—A European Natural History Museums Databank: http://www.specola.unifi.it/eva.htm

Division of Birds, National Museum of Natural History, Smithsonian Institution—for types catalogue, loans and destructive sampling protocols: http://www.nmnh.si.edu/vert/birds

eBEAC: the Electronic Bulletin for European Avian Curators

eBEAC is primarily intended for curators and collection managers of European museums, but those working elsewhere in curation or management of bird collections are not excluded.

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